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GEOGRAPHIC VARIATION IN EASTERN NORTH AMERICAN SAVANNAH SPARROWS

(*Passerculus sandwichensis*)

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In attempting to identify Ohio specimens of the Savannah sparrow, the writer was confronted with the usual difficult problem familiar to investigators in this confusing group of birds. He was not long in discovering what had already been suspected, that more than one geographic race is represented rather regularly among Ohio migrants, and furthermore, that not only are there numerous examples among the transients difficult of analysis, but that the breeding stock of the state was of doubtful racial affiliation as well. It was then realized that a thorough review of the geographic variation of Savannah sparrows breeding in eastern North America would be necessary to become personally familiar with the different characters and their combinations, as well as individual variations, found in breeding populations from as many different localities as it was possible to obtain material. In connection with this study 235 breeding birds including all the known races from North America (with the exception of Pacific coast forms) have been examined, as well as numerous migrants totaling 1,087 specimens.

Peters and Griscom in their monographic work on the "Geographical Variation in the Savannah Sparrow"[1] divided the birds of this species breeding in Canada and the United States, east of the one hundredth meridian, into five races: *Passerculus sandwichensis nevadensis* Grinnell, *P. s. oblitus* Peters and Griscom, *P. s. labradorius* Howe, *P. s. savanna* (Wilson) and *P. s. princeps* Maynard. These authors con-

[1]Bull. Mus. Comp. Zool., Vol. 80, No. 13, 1938, pp. 445–481.

sidered *P. s. bradburyi* Figgins and *P. s. campestris* Taverner as synonyms of *savanna* and *nevadensis* respectively.

These conclusions were borne out completely by the material examined in the present study, with the exception of the status of certain breeding populations included under the name *P. s. savanna*, and the identification of the type specimen of *P. s. bradburyi*.

Peters and Griscom commented on certain individual variations in specimens included by them under *P. s. savanna*. They did not, however, mention any variations in this form correlated at all with geographic distribution.

The present writer examined large series of breeding birds from Nova Scotia, New England, southern Ontario, Ohio and Michigan together with scattering specimens from regions in between; also a few from southern Wisconsin and northern Illinois and found a rather considerable amount of geographic variation. Generally speaking an increase in darkness and grayishness of plumage is noticeable in progressing westward to Michigan with a progressive paling from there on. Nova Scotia and the Magdalen Islands are inhabited by a comparatively pale, brownish bird. New England and Gaspé Peninsula specimens are noticeably darker and more grayish. From there westward there is a gradual darkening of color although northeastern Ohio and Lake Nipissing, Ontario, specimens are only slightly darker than New England examples. In northwestern Ohio and Michigan, however, specimens are noticeably darker and form the transition with *Passerculus sandwichensis oblitus* which breeds from the north shore of Lake Superior (including Isle Royale) northward and north-westward. West of Ohio and Michigan, Savannah sparrows become paler again and tend to have more slender bills, thus showing an approach to the characters of *nevadensis*. It is of interest to note that relatively the same differences are observable in the juvenals as in the adults from the same regions.

Now arises the question of what to do with these varient populations which in the aggregate make up what has been called *P. s. savanna*. If the birds from Nova Scotia are compared directly with specimens from northwestern Ohio, the difference is so extremely marked that one wonders how anyone can call them the same and still recognize *nevadensis* or *labradorius* as distinct from *savanna*. Therefore, it seems desirable to recognize more than one geographic race here.

but the question is where to draw the lines between them, and having separated them, which to call *P. s. savanna* and which the undescribed form or forms.

Here we come face to face with the disconcerting fact that the breeding range of *typical P. s. savanna* has never been defined. This form was described by Wilson from a migrant female specimen, apparently now not extant,[2] taken at Savannah, Georgia. Since it now seems likely that any one of several subspecies might be expected to occur at Savannah, Georgia, during migration it is all the more important to know which of these Wilson had in hand when he wrote his description. Fortunately a colored plate[3] accompanied this description. The plate depicts a rather pale Savannah sparrow with brown markings distinctly rufescent, and in all ways definitely more like the Nova Scotia bird than any other that the writer has examined. Therefore, it seems that birds from that region should be taken as representing typical *Passerculus sandwichensis savanna*, 42 breeding specimens and numerous migrants of which have been available for study in the Cleveland Museum of Natural History's large Nova Scotia Collection. Two late summer birds from the Magdalen Islands agree rather closely with Nova Scotia specimens and are definitely referable to *P. s. savanna*. Numerous migrant specimens from the Atlantic coast region as well as scattered examples from as far west as Ohio and Mississippi also should be referred to the Nova Scotia form.

Going westward from Nova Scotia a rather abrupt change occurs in the coloration of breeding Savannah sparrows, birds from New England being distinctly darker and more grayish. In going further westward this condition is progressively intensified culminating in the rather dark birds of Michigan and northwestern Ohio.

It seems to the writer that Nova Scotia and Magdalen Island birds are distinct enough from those breeding in New England, whence a series of 10 specimens from Maine, New Hampshire, and Massachusetts have been seen, to be separated from them subspecifically. The writer was also at first inclined to consider the northwestern Ohio and Michigan population a distinct race from the New England birds. However, in view of the fact that whereas the Nova Scotia series is at the

[2]Hellmayr. Field Mus. Nat. Hist. Zool. Ser., Vol. 13, Pt. 11, 1938, p. 486.
[3]Wilson. Amer. Orn., Vol. 3, 1811, p. 55 (pl. 22, fig. 3).

extreme end of a progressive chain of character variation (from pale brown to dark gray), the northwestern Ohio and Michigan series present characters that are intermediate between the medium gray New England series and that from Fort Churchill, Manitoba, the type locality of the blackish *P. s. oblitus*. In view of these facts it seems better to recognize only two subspecies instead of three, one in Nova Scotia and vicinity already shown to be typical *P. s. savanna* and one from New England west to the Great Plains with average characters probably presented by breeding populations in northeastern Ohio, northern Pennsylvania and western New York.

Before giving it a name, however, it is of course necessary to consider the applicability of *Passerculus sandwichensis bradburyi*, the name given by Figgins[4] to migrant Savannah sparrows taken at James Island, South Carolina. Mr. Alfred M. Bailey, of the Colorado Museum of Natural History, very kindly loaned the type of *bradburyi* together with ten other specimens from James Island used by Figgins in the description of this race. The type of *bradburyi* is one of only two specimens of the entire series *not* referable to the pale brownish Nova Scotia race that is now known to be typical *P. s. savanna*. The type and one other specimen are much darker and apparently referable to *labradorius*, which name stands by right of priority. Therefore, the medium gray southeastern Savannah sparrow definitely seems to be without a name. The writer proposes to call it:

Passerculus sandwichensis mediogriseus, subsp. nov.

SOUTHEASTERN SAVANNAH SPARROW

Subspecific Characters—Similar to *Passerculus sandwichensis savanna* but darker and more grayish (less brownish) above; streaking on underparts coarser and more blackish. Sides of head less buffy (more grayish); stripe over eye duller or more greenish yellow. Similar also to *Passerculus sandwichensis oblitus* but paler and duller (less contrastingly marked) above; streaking on underparts finer.

Measurements—Adult male (23 breeding specimens from northern Ohio); wing, 66.5–71.5 (average 69) mm.; tail, 45–52.5 (49.6); exposed culmen, 10–12 (11.1); height of bill at base, 6–7.5 (6.6); tarsus, 19–21 (19.5). Adult female (5 breeding specimens from northern Ohio); wing, 63.5–71.5 (average 66.3) mm.; tail, 42–51.5 (46.3); exposed culmen, 10.5–11.5 (11); height of bill at base, 6–7.5 (6.7); tarsus, 19–20 (19.3).

[4]Proc. Colorado Mus. Nat. Hist., Vol. 2, No. 1, 1918, pp. 2–3.

Type—Adult male, No. 29171, Cleveland Museum of Natural History; Andover, Ashtabula County, Ohio, June 22, 1931; Omar E. Mueller and John W. Aldrich, original number 1243.

Geographic Distribution—Breeds from the Gaspé Peninsula south (excluding Nova Scotia) to New England and New Jersey west to Minnesota and Iowa. South in winter to southeastern United States.

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The rather abrupt transition that is found in northern Ohio from typical *mediogriseus* conditions of the eastern section (Ashtabula, Carroll, Geauga, Portage, and Cuyahoga counties) to a strong infiltration of *oblitus* characters in the northwestern section (Erie, Lucas, and Paulding counties) is very likely due to the origin of the breeding populations in these two sections. There is rather conclusive evidence that the Savannah sparrow entered Ohio as a breeding bird at least in the northwestern section in comparatively recent times.[5] The source of immigrants into the northwestern section would naturally be from regions to the north in Michigan where one finds an approach to *oblitus* characters, while birds entering the northeastern portions of the state would most likely come in along the Lake Erie shore from the northeast through western New York and northern Pennsylvania where conditions more typical of *mediogriseus* prevail.

Specimens from northern Illinois and southern Wisconsin are slightly paler and have more slender bills than typical *mediogriseus*, but are decidedly closer to that race than to *nevadensis*.

The western limit of the range of *mediogriseus* apparently is the eastern edge of the Great Plains grassland climax in Minnesota and Iowa, while its northern limit corresponds roughly with the southern limit of the spruce-fir association from the north shore of Lake Superior through central Ontario and Quebec to the north shore of the Gulf of St. Lawrence.

A very unsatisfactory condition exists in our knowledge of the way in which *P. s. labradorius* intergrades with *P. s. oblitus* because of the paucity of material from the interior of northeastern Canada. Peters and Griscom[6] extend the range of *oblitus* as far east as Lake St. John, Quebec. A single breeding specimen marked merely "Ungava" in the collection of the

[5]Campbell. Wilson Bull., Vol. 40, 1928, pp. 223–225.

[6]Bull. Mus. Comp. Zool., Vol. 80, No. 13, 1938, pp. 445–481.

United States National Museum seems definitely referable to *labradorius*. The area of intergradation is undoubtedly a broad one as is the case between *mediogriseus*, *oblitus*, and *nevadensis*. But that *labradorius* extends its range farther west than the coast of Labrador and the north shore of the Gulf of St. Lawrence seems almost certain in view of the presence of the substantial number of migrant specimens of definitely *labradorius* affinities from the interior regions: James Bay, Sept. 14; Ontario (Lae Seut, Sept. 19; Agawa Bay, Sept. 12; and Pt. Pelee, Sept. 16 and 17); Michigan (Portage Lake, Sept. 2; Charity Islands, Sept. 13; Wayne County, May 6; and Huron County, May 24); as well as the Ohio localities listed beyond.

Identification of Ohio migrants—In light of the above outlined facts relating to the geographic variation of the Savannah sparrow in eastern North America the collection of 75 migrant specimens assembled from Ohio has been identified as follows:

P. s. labradorius.

Lucas County, Waterville Township—♀ im. Sept. 12, 1936
Ohio State Museum
Ottawa " Bay Point — Sept. 23, 1931
Cleveland Museum of Natural History
Cuyahoga " Strongsville Township ♀ Oct. 5, 1935
Cleveland Museum of Natural History
Hamilton " Ross Lake ♂ April 14, 1880
Cincinnati Society of Natural History

P. s. savanna.

Lake County, Mentor Headlands ♂ April 20, 1931
Cleveland Museum of Natural History
Delaware " Delaware ♂ March 30, 1932
Cleveland Museum of Natural History
Clermont " Union Township ♂ Oct. 25, 1936
Cleveland Museum of Natural History
Scioto " Buena Vista ♀ May 2, 1925
Cleveland Museum of Natural History

P. s. mediogriseus.

35 specimens taken in March, April and early May from all sections of Ohio.
19 specimens taken in September, October and November from all sections of Ohio.

P. s. oblitus.

Lucas County, Jerusalem Township—♂ May 10, 1936
Ohio State Museum
Lucas " " " ♀ May 26, 1939
Cleveland Museum of Natural History

Ottawa	County,	Bay Point		♀	May 18, 1926
					Cleveland Museum of Natural History
"	"	"	"	♂	May 18, 1931
					Cleveland Museum of Natural History
Lake	"	Richmond		♀	May 3, 1938
					Cleveland Museum of Natural History
"	"	"		♂	May 3, 1938
					Cleveland Museum of Natural History
Mercer	"	Grand Reservoir		♂	Oct. 19, 1911
					Ohio State Museum
Clermont	"	Union Township		—	April 1, 1934
					Ohio State Museum
"	"	"	"	♂	March 26, 1938
					Cleveland Museum of Natural History
"	"	"	"	♂	March 26, 1938
					Cleveland Museum of Natural History
"	"	"	"	♀	May 12, 1939
					Cleveland Museum of Natural History
"	"	"	"	♂	Oct. 27, 1935
					Cincinnati Society of Natural History
Pike	"	Waverly		♂	May 5, 1899
					Ohio State Museum
Scioto	"	Lucasville		♂	May 6, 1925
					Cleveland Museum of Natural History

P. s. nevadensis.

Clermont	County,	Union Township		♂	March 19, 1936
					Cincinnati Society of Natural History
"	"	"	"	♂	April 14, 1936
					Cleveland Museum of Natural History
"	"	"	"	♂	April 10, 1938
					Cleveland Museum of Natural History

This sample of migrant birds from Ohio probably gives a fairly good picture of the proportions in which different races mingle during migration just west of the Appalachian Mountains and south of Lake Erie.

A large proportion of the specimens identified as *mediogriseus* showed definite indication of approach to *oblitus* characters as would be expected since this is the case among breeding birds in northwestern Ohio and northwestward to the south shore of Lake Superior. The majority of the migrant specimens, however, seemed fairly typical of the somewhat paler northeastern Ohio or New England type. This fact, together with the finding of four migrant specimens of *savanna* in Ohio, indicates a westward drift to the migration of eastern breeding populations, while the discovery of the three specimens of *nevadensis* in extreme southwestern Ohio (Clermont County) indicates that during migration this form may move somewhat eastward from its breeding range.

In general the northward migration of *P. s. oblitus* is later than that of *mediogriseus*, the bulk of the more northern breeding birds apparently going through Ohio in May rather than April. A few late stragglers of *oblitus* even linger as late as the last week in May as is evidenced by the capture of a perfectly typical female specimen of that form in unworn plumage and with undeveloped gonads in Lucas County on May 26.

The present study was greatly aided by the excellent revisional paper on the Savannah sparrows by Peters and Griscom mentioned above. But even with the use of that very helpful treatise, completion of the task would have been impossible without the aid of a rather large amount of comparative material courteously supplied from various collections. The writer wishes to express his thanks for the loan of this material to the United States National Museum, the United States Biological Survey, the Museum of Comparative Zoology, the Museum of Zoology at the University of Michigan, the Field Museum of Natural History, the Ohio State Museum, the Cincinnati Society of Natural History, the Colorado Museum of Natural History, and the National Museum of Canada, and the private collection of Dr. Lawrence E. Hicks. For helpful advice particularly in respect to the establishment of typical *P. s. savanna* by means of Wilson's plate the writer is indebted to Dr. Harry C. Oberholser.

Perspectives in Biochemistry

Many of the most fascinating frontiers of present day science are found in the field of biochemistry. Rapid progress has recently been made in our knowledge of protein chemistry, the nature of viruses and hormones, the chemistry of genetic variations in certain flower pigments, the role of vitamins, the action of drugs on the nervous system, and various other aspects of biochemistry. The recent book, Perspectives in Biochemistry, contains thirty-one essays by authorities in biochemistry and related fields. The essays are presented with unusual simplicity and are arranged in consistent order. A bibliography is included at the end of each chapter. Each of the topics is of general interest, as indicated by the following samples: The Biochemistry of the Individual, The Meaninglessness of the Terms Life and Living, The Economy of the Bacterial Cell, The Chemical Regulation of Insect Growth, The Biochemistry of Flower Color Variation, Biochemistry and Mental Disorder, Drugs and Mankind, The Social Implications of Biochemistry. On reading this book one appreciates more fully the interdependence of the various branches of science. Thus biochemistry is closely allied with organic chemistry, phsyiology, genetics, physics and bacteriology. Perspective in Biochemistry should be available to all those wishing to keep abreast of the march of science, whether scientific laymen or workers in other fields of science.—*D. C. Rife.*

Perspectives in Biochemistry, edited by Joseph Needham and David E. Green. xxxi+361 pp. Cambridge at the University Press, New York, the Macmillan Co. 1938. $4.75.

A STUDY OF THE EFFECTS OF INCREASED IODINE FEEDING TO A HERD OF SIXTY DAIRY COWS[1]

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It is the purpose of this paper to present the results obtained in an experiment designed to determine the effects of increased iodine feeding upon a herd of sixty dairy cows. The great number of variable factors encountered, however, prevent the drawing of any final or even of comprehensive conclusions; even from the extensive data collected.

We endeavored to conduct this experiment in as scientific a manner as possible, without too greatly disturbing the routine of the dairy. The farm employees were carefully instructed and trained in the collection of specimens. The best quantitative methods available were used. Nevertheless, it must be borne in mind that such a study as this, even at its best, cannot possibly be as accurate as an investigation using laboratory animals, or even human beings under controlled hospital conditions.

The valuable herd of dairy cows used in this experiment produces *a Grade A raw milk*, which is delivered in Columbus, Ohio.[4] It was therefore necessary to protect this privately owned dairy herd by carefully observing the cows during the entire experiment. The general health of the cows, the output of milk and the quality of milk were essential factors to be conserved. The cows had been previously tested for tuberculosis, B-abortus and mastitis.

LITERATURE

A brief review of the literature is first presented in order to consider the various effects of increased iodine feeding which have been thus far reported. Several investigators have previously used both laboratory and domestic animals, as well as hospital patients.

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[1]This investigation was aided by a grant from The Iodine Educational Bureau, Inc., of New York City.

[2]William Wallace Kincaid Fellow in Research Surgery.

[3]Publication of this investigation was made possible by a Grant from The Comly Fund for Medical and Surgical Research of The Ohio State University.

[4]We express our thanks to Mr. Dan Schaaf and his coworkers for their assistance.

Marine (1) as early as 1907 stated that iodine-containing salts had been fed to Michigan sheep to prevent the high death rate ordinarily then occurring among the new-born. Ten years later Smith (2) observed the abnormal condition which he called "Fetal Athyreosis." This state in new-born pigs is characterized by an enlarged thyroid gland, thickened skin, hairlessness or weakness, and often by still-birth. Smith estimated that as many as 10,000 animals were lost annually in Montana. Kalkus (3) reported a high incidence of "Fetal Athyreosis" in horses, cattle, sheep and goats. Furthermore, breeding difficulties have also been described in pigs of North Dakota (4) and Wisconsin (5), and similar observations have been made elsewhere (6) (7).

Hanzlik (8) showed that supplemental iodine feeding is a factor in the rate of growth of laboratory animals. He observed, moreover, that rats having a diet rich in iodine maintain a better general condition than those without such a supplement.

Evvard and Culbertson (9) observed an increase in the rate of growth of domestic animals subsequent to the addition of iodine to the diet. They fed 5 milligrams, 43 milligrams and 55 milligrams of potassium iodide per day to a total of 36 pigs. The increase in the rate of growth averaged ten per cent for all the pigs even though they ate ten per cent less food. Kelly (10) reported similar results in the growth of young pigs. Weiser and Zaitschek (11) studied the size of the litter and the weight of the offspring. They fed 125 milligrams of potassium iodide per day to sows during the last three weeks of gestation and the first ten weeks of lactation. Of the non-iodized group 3.8 pigs per litter were raised whose average weight at the end of ten weeks of lactation was 13.2 kilograms. Of the iodized group 7.6 pigs per litter were raised whose average weight was 18.5 kilograms. Other investigators (12) (13) found no essential differences in the weights of pigs fed amounts of potassium iodide varying up to one gram.

The effect of increased iodine feeding upon the milk production of cows was studied by Stiner (14), Scharrer (15), Weiser and Zaitschek (11) and Thomson (16). Stiner in 1924 observed that the addition of iodine to the diet of cows resulted in an increase of milk production over controls. Scharrer and his group increased the milk yield 5–10 per cent by adding large quantities of iodine, 100 to 600 milligrams per day, to the diet of the cows. Weiser and Zaitschek obtained a seven per cent

increase in milk production by feeding 125 milligrams of potassium iodide per day.

More recently Thomson (16) made a comparative study on Ayrshire cows over a period of five years. He used eight cows as controls and fed seven cows 90 milligrams of iodine per day. For the five-year period the non-iodized group produced 788 gallons of milk per cow per year while the iodized group produced only 747 gallons per year. However, a comparison of these values with those of the first year, in which the non-iodized cows produced 749 gallons and the iodized cows 626 gallons, show that the iodized cows registered larger gains. Thomson did not attempt to draw any significant conclusions from this extensive study.

The normal iodine content of cows' milk has been determined by numerous investigators. The average iodine content of milk in goitrous areas is 2.9 mcg. per cent,[5] but this result is based upon a limited number of determinations (17). Hanford, Supplee and Wilson (18) obtained average values of 6.9 in South Carolina, 3.2 in Wisconsin and 2.7 mcg. per cent in New York.

European investigators, as well as investigators in our own country, have studied the milk iodine values of cows receiving increased iodine feeding. Scharrer and Schwaibold (19) obtained milk with only 28.9 mcg. per cent iodine from cows fed 100 milligrams per day, 37 mcg. per cent for 200 milligrams fed per day, and 212 mcg. per cent for 600 milligrams fed per day. Hanford, Supplee and Wilson (18) found 25, 40.3 and 181.3 mcg. per cent on feeding 3.1, 46. 3 and 198 milligrams per day, respectively. The milk iodine of the control cows was 6.1 mcg. per cent. Orr and Leitch (20) obtained 33 mcg. per cent by feeding 180 milligrams per day whereas they obtained only 4 to 7 mcg. per cent for their control cows. McHargue (21) elevated the iodine in milk to 40 mcg. per cent by feeding iodine.

Other European investigators (22) (23) (24) have shown that the iodine content of milk from cows and milking goats increases following increased iodine feeding. None of the above investigators reports any deleterious effects from the increased iodine intake.

A previous investigation made within our group (25), using a herd of Brown Swiss Cows, showed that upon the addition of approximately 94 milligrams of iodine per day the iodine content of the milk was found to vary from 0.016 to 0.182 mcgm. per

[5]This represents 29 parts of iodine per billion of milk.

cent, which is a great increase over the normal milk iodine. A definite increase in blood iodine, urinary excreted iodine and fecal iodine was also observed. Since, however, no control cows were available, a comparative study was impossible.

METHODS

Two breeds of cows, Holstein and Guernsey, numbering 30 each, were used in this experiment. These cows were kept in their normal environment. A study of the cows was made during the Fall of 1935 and the Winter, Spring and Summer of 1936. The major portion of the study was conducted during the colder months, November to April, when the cows were kept under shelter. Later, observations were made when the cows were turned out to pasture.

Before any increased iodine feeding was instituted, it was found desirable to obtain a rough idea as to the status of the normal iodine "balance" of the cows to be studied. Blood was obtained by vena puncture from each of the sixty cows on November 19, 1935, for the determination of iodine. On December 14 to 15, 1935, and on February 15 to 16, 1936, two one-day "balance" studies were made. Representative samples for the determination of the iodine content of the feed intake (water, ensilage, alfalfa hay and a grain mix) were also obtained and analyzed.

Since the collection of specimens for the determination of iodine in the excreta required a constant attendant, only six Holstein and six Guernsey cows were studied. These were chosen at random, to represent their respective groups. Great care was exercised to obtain and record all the excreta for the 24-hour period. A representative sample of the pooled specimens of urine and feces was taken for analysis. The amount of milk yielded in the 24-hour period was carefully recorded and a composite sample of the two milkings (3:00–5:00 A. M. and 2:00–4:00 P. M.) was taken for analysis.

On February 16, 1936, the Holstein and Guernsey groups of cows were divided into two groups, each composed of 15 cows. From this time on 15 Holstein and 15 Guernsey cows were fed continually a grain mixture which contained by actual analysis 3.2 milligrams of iodine per 100 grams of feed. The Ubiko Milling Company of Cincinnati, Ohio,[6] furnished this iodized

[6]We express our thanks to the Ubiko Milling Company for its cooperation in this study.

mixture, a feed prepared as one-twenty-thousandth potassium iodide or 3.4 milligrams of iodine per 100 grams of feed. Calculations show that the iodized Holstein cows received an average of 131 mg. of iodine and the iodized Guernsey cows an average of 95 mg. of iodine per day throughout the year.

The uniodized grain mixture which was fed to the control group was obtained from the same company. This feed was essentially the same as that which had been fed both groups from December 4, 1935, to February 16, 1936.

It was expedient to duplicate the "balance" studies as of the first part of the experiment previous to the institution of increased iodine feeding. Therefore, on April 14, 1936, blood samples were again obtained from all the cows. Milk samples were obtained which were representative of the 24-hour secretion on April 17 to 18, 1936.

The third "balance" study was made on three cows for each of the four groups (non-iodized Holstein and Guernsey and iodized Holstein and Guernsey). This "balance" study was conducted as was the experiment before iodinization. From the iodized cows of both breeds, for a period of five months (June to October, 1936), composite samples of milk were obtained three mornings a week for iodine analysis.[7]

All the specimens were analyzed for iodine by means of the Matthews, Curtis and Brode method (26). This method has been carefully tested, and yields results precise to 5 per cent under ideal conditions.

The official dairy tester measured the amounts of feed that the cows were receiving on April 16, May 22, June 12, July 17, August 26, September 18 and October 15, 1936. From these measurements the average amounts of iodine received by both the Guernsey and Holstein cows in the grain mixture were calculated for these dates as 128, 67, 82, 113, 125, 120 and 118 milligrams per day, respectively.

RESULTS

The results of this experiment are best presented in table form. For convenience the non-iodized cows have been called Group I and the iodized cows Group II.

[7]The results of feeding of the iodized milk to hospital patients will be reported in a subsequent publication.

Table I presents the blood iodine values in November before supplemental iodine feeding was instituted, and in April after iodinization. Figure 1 illustrates graphically the marked elevation of the blood iodine subsequent to the increased iodine intake.

The results of the one-day "balance" studies are presented as averages and are as accurate estimations as possible. The data obtained in the three "balance" studies are shown in Table II for each of the individual cows. Table III presents the group averages of the "balance" studies which are graphically presented in Figure II.

TABLE I

Blood Iodine Values

Time of Test	Breed of Cow	Group	Number of Cows Tested	Average Amount of Iodine (in mcg.) in 100 cc. of Blood	Mean Deviation from Average
Nov., 1935	Holstein	I & II	26	4.02	.95
Nov., 1935	Guernsey	I & II	27	3.82	.77
April, 1936	Holstein	I	14	4.85	1.24
April, 1936	Holstein	II	13	57.10	12.10
April, 1936	Guernsey	I	8	6.25	2.4
April, 1936	Guernsey	II	10	55.60	9.2

The blood iodine values of the non-iodized Holstein and Guernsey cows in November, 1935, and of the iodized and non-iodized cows of both groups in April, 1936.

An attempt was made to determine whether the iodine in the iodized milk was in fat or protein combination. The fat was removed by the Rose-Gottlieb (27) method and the protein by the method of Osborne and Mendel (28). From 80 to 90 per cent of the iodine remained after removal of the fat and protein. In this respect our observations confirm those of Scharrer and Schwaibold (19), who likewise studied milk from cows fed relatively large amounts of potassium iodide. They, too, found little iodine in protein or fat combination.

Other data pertaining to milk and butter-fat production, calf records, general health of the normal control cows and iodized cows will be presented by Professor O. Erf, who has collaborated in this work.

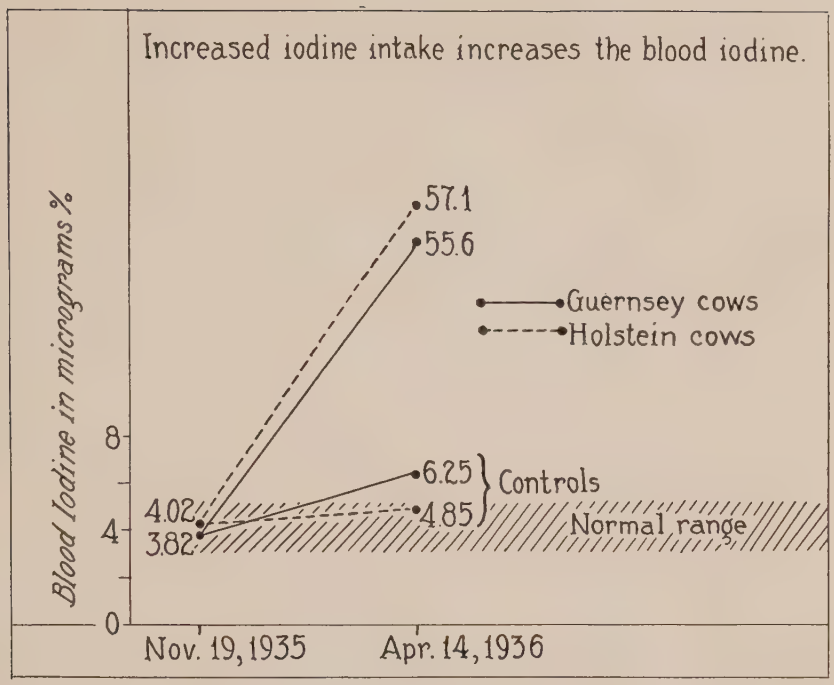

FIG. 1. Marked elevation of the blood iodine subsequent to increased iodine intake by the Holstein and Guernsey cows.

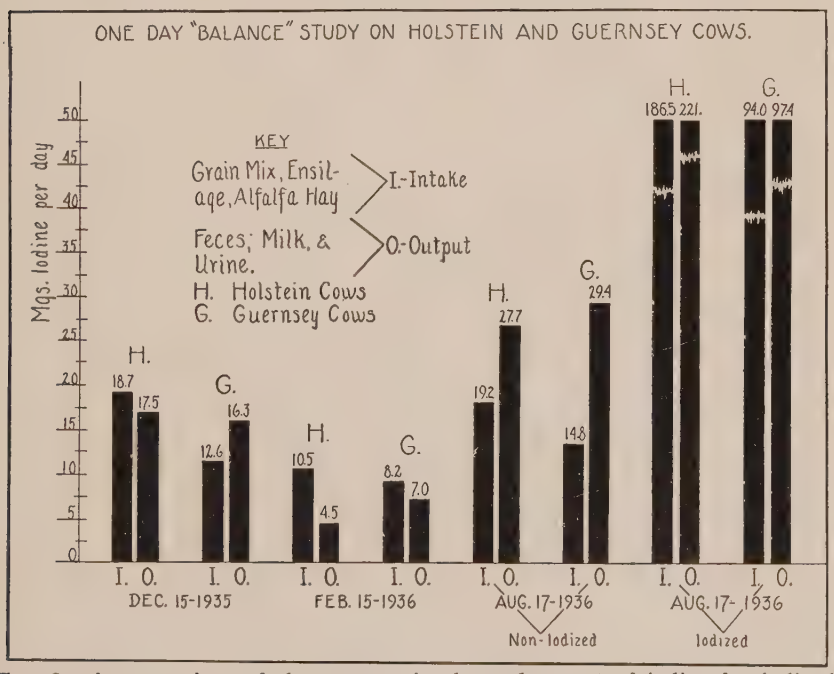

FIG. 2. A comparison of the average intake and output of iodine for iodized and non-iodized Holstein and Guernsey cows on December 15, 1935, February 15, 1936, and August 17, 1936.

TABLE II

METABOLISM STUDIES OF COWS

Date	The Number of the Cows	Breed	Estimated Food Intake Per Day							Estimated Iodine Excretion Per Day							Balance mg.
			Alfalfa Hay		Ensilage		Grain Mix		Total Iodine Intake mg.	Urine		Milk		Feces		Total Iodine Excretion mg.	
			Weight kg.	Iodine Content mg.	Weight kg.	Iodine Content mg.	Weight kg.	Iodine Content mg.		Volume liters	Iodine Content mg.	Volume liters	Iodine Content mg.	Weight kg.	Iodine Content mg.		
December 14–15, 1935	56	Holstein	7.3	2.3	15	8.0	5.5	10.2	20	8.6	2.4	19.0	2.6	45	13.0	18	+ 2
	57	"	7.3	2.3	15	8.0	4.1	7.7	18	8.6	2.4	6.6	1.9	27	8.0	12	+ 6
	59	"	7.3	2.3	15	8.0	4.5	8.5	19	9.1	2.4	8.1	4.4	41	16.0	23	— 4
	1	"	7.3	2.3	15	8.0	4.5	8.5	19	5.9	1.8	16.0	3.0	27	6.5	11	+ 8
	3	"	7.3	2.3	15	8.0	3.6	6.8	17	8.2	3.7	13.0	2.8	35	17.0	24	— 7
	5	"	7.3	2.3	15	8.0	4.5	8.5	19	5.7	1.6	15.0	1.7	37	13.0	16	+ 3
	17	Guernsey	5.5	1.7	12	6.2	2.7	5.1	13	8.2	9.8	8.3	2.1	28	15.0	27	—14
	18	"	5.5	1.7	12	6.2	2.7	5.1	13	6.4	2.9	4.5	.6	23	4.9	8	+ 5
	19	"	5.5	1.7	12	6.2	2.7	5.1	13	6.4	6.7	4.9	1.5	20	9.2	17	— 4
	42	"	5.5	1.7	12	6.2	2.3	4.3	12	7.3	3.3	1.3	.2	27	8.7	12	0
	43	"	5.5	1.7	12	6.2	2.3	4.3	12	9.5	7.5	4.1	.6	26	10.0	18	— 6
	45	"	5.5	1.7	12	6.2	2.3	4.3	12	8.2	4.6	5.4	1.5	21	8.6	15	— 3
February 15–16, 1936	56	Holstein	7.5	6.0	15	3.6	5.6	1.4	11	7.8	1.3	14.0	.3	30	2.7	4.3	+ 7
	57	"	7.5	6.0	15	3.6	1.9	.5	10	4.7	.7	3.3	.1	14	3.4	4.2	+ 6
	59	"	7.5	6.0	15	3.6	1.9	.5	10	6.9	1.0	3.1	.1	29	3.5	4.6	+ 5
	1	"	7.5	6.0	15	3.6	3.8	1.0	11	5.1	.7	15.0	.4	27	4.9	6.0	+ 5
	3	"	7.5	6.0	15	3.6	2.8	.7	10	1.8	.4	8.3	.4	23	3.4	4.2	+ 6
	5	"	7.5	6.0	15	3.6	4.7	1.2	11	4.1	.6	13.0	.4	30	4.2	5.2	+ 6
	43	Guernsey	5.6	4.5	12	2.9	4.7	1.2	9	12.0	4.5	12.0	.5	15	3.4	8.4	+ 1
	44	"	5.6	4.5	12	2.9	3.8	1.0	8	2.1	.2	11.0	.3	22	8.9	9.4	— 1
	45	"	5.6	4.5	12	2.9	3.3	.8	8	5.0	.6	9.1	.2	22	2.5	3.3	+ 5
	17	"	5.6	4.5	12	2.9	2.3	.6	8	3.6	1.6	6.4	1.2	15	5.7	8.5	— 1
	19	"	5.6	4.5	12	2.9	1.9	.5	8	3.4	.4	3.6	.5	11	3.3	4.2	+ 4
	20	"	5.6	4.5	12	2.9	2.3	.6	7	5.8	.7	6.1	.6	17	7.1	8.4	— 1

TABLE II—(Continued)

METABOLISM STUDIES OF COWS

Date	The Number of the Cows	Breed	Estimated Food Intake Per Day							Estimated Iodine Excretion Per Day							Balance mg.
			Alfalfa Hay		Ensilage		Grain Mix		Total Iodine Intake mg.	Urine		Milk		Feces		Total Iodine Excretion mg.	
			Weight kg.	Iodine Content mg.	Weight kg.	Iodine Content mg.	Weight kg.	Iodine Content mg.		Volume liters	Iodine Content mg.	Volume liters	Iodine Content mg.	Weight kg.	Iodine Content mg.		
August 17–18, 1936	56	Holstein	12.0	6.7	20.0	2.2	8.0	7.7	16.3	8.2	3.7	5.1	1.2	40	27.0	32	— 20
	57	"	12.0	6.7	20.0	2.2	12.0	11.6	20.3	13.0	.7	21.0	5.3	38	15.0	21	— 2
	58	"	12.0	6.7	20.0	2.2	12.0	11.6	20.3	20.0	5.0	11.0	4.3	40	22.0	31	— 14
	2	"	12.0	6.7	20.0	2.2	10.0	145.0	154.0	16.0	61.0	13.0	18.0	37	94.0	173	— 52
	4	"	12.0	6.7	20.0	2.2	14.0	210.0	219.0	14.0	66.0	27.0	74.0	50	157.0	297	—116
	8	"	12.0	6.7	20.0	2.2	12.0	175.0	184.0	11.0	56.0	24.0	49.0	46	87.0	192	— 11
	43	Guernsey	9.3	5.5	15.0	1.6	8.0	7.7	14.8	15.0	10.0	9.5	1.0	23	9.0	20	— 7
	44	"	9.3	5.5	15.0	1.6	8.0	7.7	14.8	10.0	40.0	4.0	.4	25	9.0	49	— 37
	45	"	9.3	5.5	15.0	1.6	8.0	7.7	14.8	13.0	5.0	9.2	2.0	23	12.0	19	— 7
	16	"	15.0	5.5	15.0	1.6	6.0	87.0	95.0	8.2	29.0	9.7	10.0	29	79.0	118	— 27
	17	"	15.0	5.5	15.0	1.6	4.0	58.0	85.0	12.0	5.0	1.0	.8	16	33.0	39	+ 40
	18	"	15.0	5.5	15.0	1.6	8.0	116.0	123.0	15.0	50.0	4.4	5.5	32	81.0	137	— 29

The intake and output of iodine of Holstein and Guernsey cows, iodized and non-iodized, on December 14–15, 1935, February 15–16, 1936, and August 17–18, 1936.

TABLE III

"Balance" Studies on the Groups of Cows

Date	No. of Cows	Breed	Mgs. of Iodine Ingested Per Day (Averages)				Mgs. of Iodine Excreted Per Day (Averages)			
			Alfalfa Hay	Ensilage	Grain Mix	Total	Urine	Milk	Feces	Total
12–15–35	6	Holstein	2.3	8.0	8.4	18.7	2.4	2.7	12.4	17.5
12–15–35	6	Guernsey	1.7	6.2	4.7	12.6	5.8	1.1	9.4	16.3
2–15–36	6	Holstein	6.0	3.6	0.9	10.5	0.8	0.3	3.4	4.5
2–15–36	6	Guernsey	4.5	2.9	0.8	8.2	1.3	0.5	5.2	7.0
8–17–36	3	Holstein	6.7	2.2	10.3	19.2	3.1	3.4	21.0	27.7
8–17–36	3	Holstein	6.7	2.2	176.6	186.5	61.0	47.0	113.0	221.0
8–17–36	3	Guernsey	5.5	1.6	7.7	14.8	18.3	1.1	10.0	29.4
8–17–36	3	Guernsey	5.9	1.6	87.0	94.0	28.0	5.4	64.0	97.4

The average intake and output of iodine of non-iodized and iodized Holstein and Guernsey cows on December 15, 1935, January 15, 1936, and August 17, 1936.

DISCUSSION

The determination of the blood iodine of the normal cows by the Matthews, Curtis and Brode method (26) yields iodine values which approximate our values obtained for human blood by the same method. Previous to this study blood iodine values obtained by numerous investigators were, with one or two exceptions, at a much higher level. Other investigators (29) (30) (31) present values which confirm the more recent lower level. In the hands of experienced workers the newer methods have yielded iodine values which are comparable to the values obtained in this study.

The blood iodine values for the Holstein cows previous to increased iodine feeding averaged 4.02 mcg. per 100 cubic centimeters of blood, while those of the Guernsey cows averaged 3.82 mcg. per 100 cubic centimeters of blood. This slight difference is probably not significant. In the April study the blood iodine values of the non-iodized cows were higher than in the November study. These higher values may be due to a slight contamination of the feed or to a seasonal variation; on the other hand, they may not be significantly different from those obtained in November in view of the large average mean

deviations and the smaller numbers of non-iodized cows in April, one-half those in November.

The blood iodine values of the iodized cows were approximately ten times higher than those of the non-iodized cows. The increase in the amount of iodine in the blood of iodized cows with respect to the non-iodized cows of both groups in November is of the order of 1300 per cent and approximately the same for the Holstein and Guernsey cows. With respect to Group I in April, the per cent increase is of the order of 1000. This illustrates the effectiveness of the amount of iodine being fed in reaching the blood stream, and consequently in maintaining a much higher level of available iodine for utilization by the body.

In a former study within our group the blood iodine of the iodized cows averaged 54.9 mcg. per 100 cubic centimeters of blood, a value comparable with values obtained in this study; 55.6 mcg. per cent for Guernsey and 57.1 mcg. per cent for the Holstein cows.

During the month of April the milk iodine reflected to a greater degree than the blood iodine the different levels of iodine fed to the two groups.

The data of the "balance" studies is only approximate, since accurate estimations of food intake, the obtaining of representative samples of food for analysis and the collection of excreta were difficult. The amount of iodine ingested in the water was considered negligible since the iodine content of the water was found to be only 0.5 mcg. per cent.

The December "Balance" Study

In the December study the six Holstein and the six Guernsey cows were nearly in balance. The average iodine intake for the Holstein cows, the greater part of which was found in the grain mixture, was 18.7 milligrams per day. The average output was 17.5 milligrams per day, which is only 1.2 milligrams below the intake. The greatest channel of excretion was the feces. The Guernsey cows during the same period were also nearly in balance. The average iodine intake of 12.6 mg. was below that of the Holstein cows. The output of 16.3 milligrams per day was lower than the output recorded by the Holstein cows, being 17.5, and only 3.7 milligrams per day above the intake. Here again the largest amount of iodine was excreted by way of the feces. Both the Holstein and Guernsey cows received most of their iodine from the ensilage and grain mixture.

The February "Balance" Study

In the February study the Holstein cows were in positive balance. The average iodine intake was 10.5 milligrams per day, 6.0 milligrams above the output. The Guernsey cows during this period were approximately in balance, the average iodine intake of 8.2 milligrams per day being 1.2 milligrams per day above the average output of 7.0 milligrams per day.

The February "balance" was on the whole at a lower level than the December "balance"; both the intake and the output of the Holstein and Guernsey cows were on a lower level. Whereas the ensilage and grain mixture each furnished the largest amounts of iodine in December, the alfalfa hay was the chief source in February. The feces, as in the December study, was the largest channel of excretion of iodine.

The August "Balance" Study

The August "balance" study for a period of increased iodine feeding shows a quite different picture. Of both the non-iodized cows and the iodized cows, Guernsey and Holstein, all but one were in negative balance. This negative balance averages 12 milligrams and 17 milligrams per cow, respectively, for the non-iodized Holstein and Guernsey cows of the controls. The non-iodized Holstein cows showed an intake of 19.1 milligrams per day and an output of 27.7 milligrams per day. The non-iodized Guernsey cows were in still greater negative balance, showing an intake of 14.8 milligrams per day and an output of 29.4 milligrams per day. Of the iodized cows the Holstein average intake was 186 milligrams per day and the output 221 milligrams. The iodized Guernsey intake was 94 milligrams per day and the output averaged 97.4 milligrams per day. The ratios of intake to output for the month of August are slightly less than 1.0, in all cases but one, in contrast to the ratios for December and February, which are in general slightly greater than 1.0.

The differences between intake and output are greater for iodized cows and therefore more negative. However, a comparison of ratios will show that it is impossible to say that either the iodized cows or the non-iodized cows were in greater negative balance. It is true, though, that for a greater iodine intake there was a greater output. In actual figures the iodine output of the iodized cows was seven to nine times that of the non-iodized cows in the case of the Holsteins, but only three to four

times in the case of the Guernseys. The feces was again found to be the predominant channel of excretion of iodine for both the Holstein and the Guernsey cows.

The iodine intake of the cows during this period of pasturage varied greatly. The alternating drought and rain varied both the amount of exercise the cows obtained and the amount of food consumed. When pasturage was available, less feed and more grass was consumed. The reverse was true when none was available. Of all the feeds the grain mixture at this time contained the highest concentration of iodine.

The great negative balance of the cows may be due to (1) increased consumption of unaccountable iodine; (2) increased activity of the cows during pasturage; (3) continued excretion of iodine previously ingested in larger amounts.

To explain the great variation of the composite milk samples collected during the mid-year, the following facts must be considered. During the late spring and early summer the pasturage was abundant. Simultaneously iodized cows were fed lesser amounts of grain mixture containing added potassium iodide. In midsummer the grass in the pastures became scarce because of the extensive drought. Beginning late in June the cows were fed larger amounts of grain mixture.

An average analysis of a few grains and hays in goitrous regions yielded a result of 30 mcg. per cent (32). Forbes et al (13) found only 10 mcg. per cent in Pennsylvania. Remington and Supplee (33) found an average of 45 mcg. per cent for hog feed in South Carolina.

Ohio is generally considered to be a goitrous region. Several factors, however, may vary the iodine content of the plants of the pasture. Commercial fertilizer has been shown by investigators (20) to increase the iodine content of plants. Also, the feces of the cows, especially those receiving increased iodine feeding, would be a source of iodine for the plants.

Our determinations in February on the milk iodine values of our control cows were similar to those of other investigators mentioned in the literature. Those in April on the non-iodized cows were slightly higher. Those in December and in August were much higher.

The values of the iodine content of the milk of the iodized cows contrast with those obtained by authors mentioned in the literature. Our values for Holstein and Guernsey cows in April were 203 mcg. and 149 mcg. per cent respectively, and beginning

May 23 they averaged 80 mcg. per cent for the five months midyear (34).

The effectiveness of the use of milk containing increased iodine as a goiter prophylactic has been demonstrated both for man (35) and for experimental animals (36).

SUMMARY

Since this study, unlike our previous investigation, involved a control group of both breeds of cows used, several features of the increased iodine feeding may be noted.

No deleterious effects of the increased iodine feeding were detected. The iodized cows were apparently in as good health as the non-iodized cows.

The iodized cows were found to have blood iodine values ten times that of the control cows, a difference approximately of the order of 1000 per cent. It should be noted that the blood iodine values of the control cows are comparable to the values obtained for normal human blood.

In the "balance" studies an outstanding feature is that increased iodine feeding to dairy cows results in increased iodine content of the milk. Variations, however, do occur in the ratio of iodine in the milk to the total amount of iodine ingested. Where the iodine content ingested is increased tremendously, the increase in iodine in the milk may be even far greater than that expected from the consideration of a direct proportion. The dependence of the amount of iodine in the milk upon the amount of iodine in the food is thus firmly established. The amount of iodine in the milk seems to be independent of the volume of milk produced by the cow.

On high iodine intake the iodine in the milk is much greater than the iodine in the blood; on low iodine intake the iodine in the milk may be below the normal value.

The ratio of iodine intake to output is in all cases approximately equal to 1.0, being greater than 1.0 for the months of December and February and slightly less than 1.0 in August, a month in which the balance was consistently negative. The feces was in all cases the chief channel of excretion of iodine, approximately 70 per cent of the output of iodine being through this channel.

Feeds of the control cows were found to be considerably higher in iodine content than those reported from other goitrous regions. Similarly, milk from these cows was found to contain a larger concentration of iodine.

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Destructive and Useful Insects

Economic entomologists welcome the appearance of the improved and enlarged second edition of "Destructive and Useful Insects" by Metcalf and Flint. Several new features are decided additions to the book, particularly the keys to orders for adults and immature stages of insects. If the keys, especially those to immature stages, prove to be good ones, entomologists in general will be greatly pleased. The authors have also assigned a number to each insect as it is discussed under a given crop. These numbers appear after the name of the insect wherever it is discussed. This makes it possible to locate all of the information in the text on a particular insect without the use of the index. Many changes and improvements have been made on the control recommendations for many of the pests. The book is profusely illustrated. Some of the illustrations show signs of wear. These might have been omitted or improved. The number of pages in the second edition is 981 compared with 918 for the first edition. The authors are to be congratulated on the quality of the book produced. It has been a distinct pleasure to review this most useful book.—*A. Peterson.*

Destructive and Useful Insects, by C. L. Metcalf and W. P. Flint. xii+981 pp. New York, the McGraw-Hill Book Co., 1939. $7.50.

THE STRUCTURE AND THICKNESS OF THE CLINTON AND BEREA FORMATIONS IN THE VICINITY OF WOOSTER, OHIO

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INTRODUCTION AND ACKNOWLEDGMENTS

The data used in the construction of the structure maps were obtained from well records, filed at the field offices of the oil and gas companies operating in the area, and from the Ohio State Geological Survey. The purpose is to give one information on the structure of the Clinton and Berea formations and their thickness throughout the area. With the exception of an earlier report,[1] based on available well records at that time, no other information has been published. Many wells have been drilled since 1915 and more complete information is now available.

The writer acknowledges the aid given by Alan Leeper and George Miner, students in the Department of Geology, who plotted the structure obtained from data based on well records.

THE CLINTON AND BEREA FORMATIONS

The Clinton sand is the horizon from which the oil and gas are produced in largest quantities in the area. This formation is composed of sandstones, shales and interbedded limestone. The color of the Clinton is gray to reddish and the thickness may be as much as 85 feet. To the south this formation is more calcareous; crinoid stems are abundant and there is much resemblance to marble in some localities. The sand from which production is greatest is near the bottom of the group and some geologists consider it a part of the Medina. At several places, stray sands are found just above the Clinton, and are often reported as "red rock." Perhaps this is the bed which thickens to the east and becomes iron ore. To the westward the Clinton thins out and is a shale just beyond the center of Ohio. Here it is a fine-grained deposit which requires that the well be shot in order to obtain any production. In the southern part of Ohio, the Clinton is not a good reservoir and contains more limestone; the sand is more porous in central

[1]Bonine. Structures in the Clinton Sand. Bull. U. S. G. S. 1915, pp. 89–92.

Ohio and is consequently more productive there. The composition of the Clinton, varying as it does in different areas, has been a foremost factor in the determination of the oil and gas fields. Productive areas occur as far to the northwest as Sandusky but the best field in the Clinton is in central Ohio.

The Berea formation is described with the Clinton because of its importance as a key for that horizon. The Berea Grit is of lower Carboniferous age and in the Wooster area lies about 600 feet below the surface. The Berea underlies more than one-third of the state, with little variation in its composition. It is a moderately fine, siliceous sandstone, which is widely

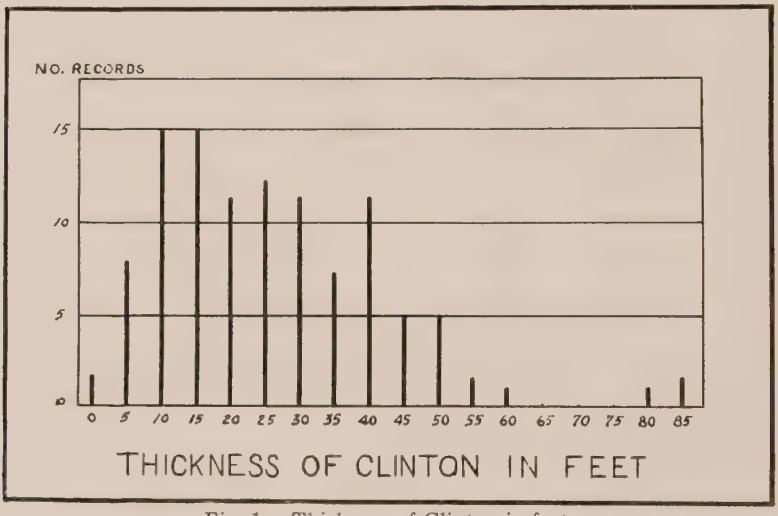

Fig. 1. Thickness of Clinton in feet.

used as a building stone. It is important as a reservoir for oil, gas and salt water. In the Wooster area, only small producers of oil and gas are present. Here it serves as an important key to the drillers seeking the Clinton. Although the Berea does not show as much folding as the Clinton, enough similarity does exist so that the Clinton structure can be interpreted by drilling to the Berea. It averages about 30 feet in thickness, varying from nothing to 150 feet. It is medium-grained and gray to buff in color; except for small areas having a high carbonate of lime content, the composition is quite uniformly a siliceous sandstone. The variation in thickness of the Berea is probably explained by the fact that it lies on an uneven surface. The data is from well records in Wooster, Plain and Franklin Townships, all in Wayne County.

GEOLOGIC STRUCTURE

In the Wooster field, the granite base upon which lie the sedimentary rocks is probably 5,000 or more feet below the surface. The area lies along the east flank of the Cincinnati arch, the strata dipping eastward as much as 50 feet per mile in some places. Erosion has removed most of the Allegheny and Pottsville formations which originally covered the area.

The most important feature of the structure is the cross-folding which has occurred; this is true over nearly all of Ohio. The existing folds are at right angles to each other, having general trends of northeast-southwest and northwest-southeast.

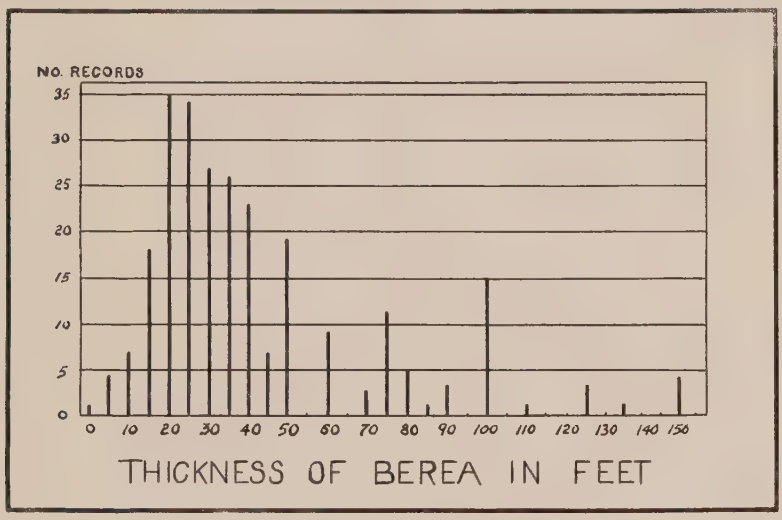

Fig. 2. Thickness of Berea in feet.

It would be a very interesting study to determine the exact nature of the two sets of forces involved in the formation of these anticlines. The folds trending northeast-southwest, in all probability, were developed by the same forces which produced the Appalachian folds. The anticlines of this region represent the gradually declining waves as the forces diminished to the westward. Less is known about the folds trending northwest-southeast, and it is this particular group which would bear more investigation. Both sets of folds occur widely distributed throughout Ohio, and it is possible that other stresses besides those which formed the Appalachians are responsible for the northwest-southeast folds. The existence of the two systems of anticlines complicates the geologic

structure and makes drillers less certain of successful results. Evidence points to the fact that the Clinton has been folded more than the Berea, probably because the Clinton was subjected to folding forces before the deposition of the Berea. Such a high degree of similarity exists in the structure of the Clinton and Berea, that drillers often use the latter to determine the structure of the Clinton. There is a belief by many that

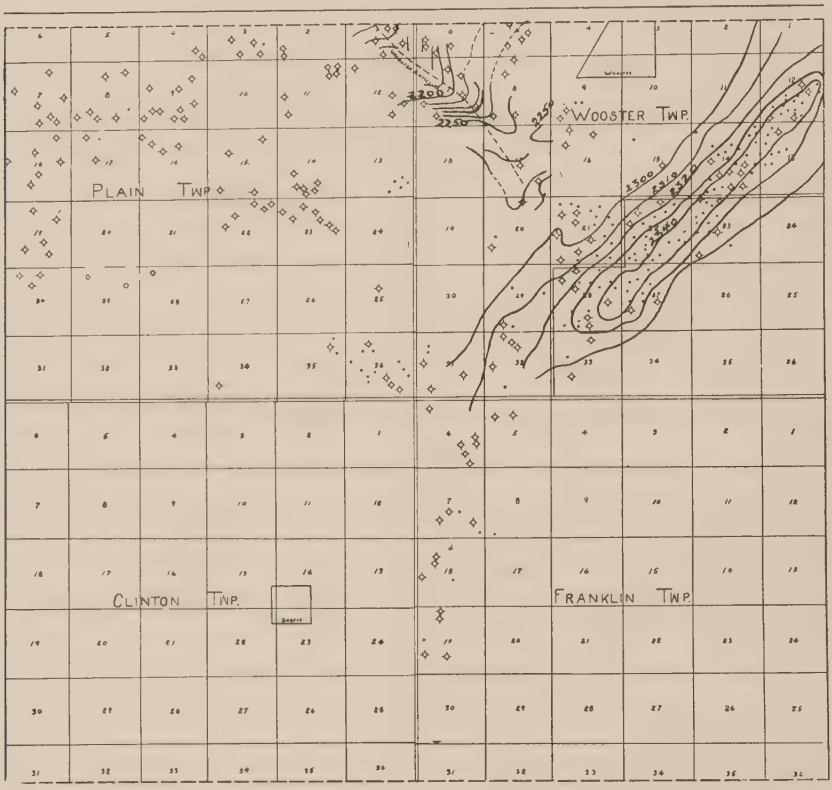

Fig. 3. Structure of the Clinton sand. Structural contours indicate the elevation below sea-level of the Clinton sand.

no relation exists between the folds and the oil and gas pools in the region. In the vicinity of Wooster this is not the existing condition. Extensive drilling has proved that the production of a well depends upon its location with respect to geologic structure. In the field southwest of Wooster, production has been best along the axis and flanks of an anticline. In supporting the view that structure is most important, one must consider the numerous pools caused by terrace structure or

"arrested dips," as they are sometimes called. These are the results of a leveling-off of the strata which otherwise dip about 50 feet per mile. Slight folding or change in dip toward horizontality is sufficient to prevent further migration up-dip of the oil or gas. Small pools exist where variations in thickness occur. Since the Clinton sandstone varies considerably in thickness within short distances, a thick patch of the formation

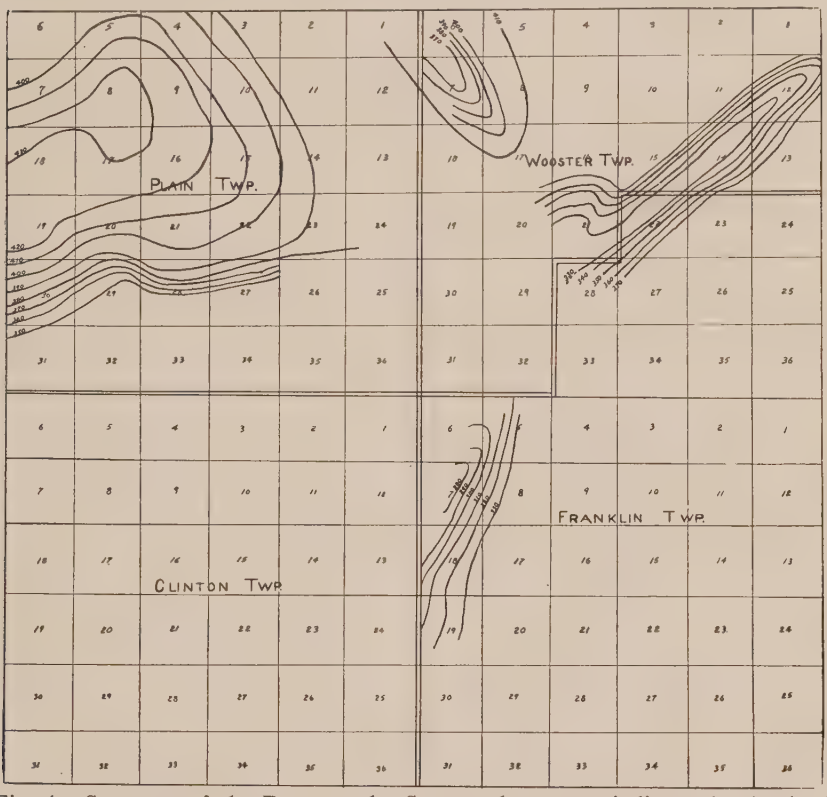

Fig. 4. Structure of the Berea sand. Structural contours indicate the depth of the top of the Berea sand from the well-head elevations.

can serve as a reservoir for oil and gas in the same manner as an anticline. As wells do not maintain their initial production very long in this area, strength was given at first to the theory that structure is not important. It is sufficient to say that best results are obtained where structure is given consideration.

The composition of the Clinton is also a deciding factor in determining where oil and gas can accumulate. A coarse-grained sandstone is better than a compact shale or limestone.

Not only does the Clinton vary in thickness in this area, but it changes in composition. A complete change is found to the west where it becomes shale, or to the south where it is calcareous. On the whole, the composition of the Clinton, as far as its oil-bearing possibilities are concerned, is at its best in the central portion of the state.

Wells in the Wooster area are considered very good producers if their initial production is above 10,000,000 cubic feet of gas per day. To obtain these results, a rock pressure of about 1,200 lbs. per square inch is required. A well is considered to be doing well if it operates at 500,000 cubic feet after 20 months, as the rock pressure has probably diminished to about 200 lbs.

GENERALIZED SECTION OF THE ROCKS PENETRATED IN DRILLING FOR OIL AND GAS IN THE WOOSTER AREA.

SYSTEM	FORMATION	DRILLERS NAME	THICKNESS	CHARACTER
Quarternary	Glacial	Sand and Gravel	0–100	Boulder, clay, sand, pebbles, shale fragments and boulders.
Carboniferous	Logan and Cuyahoga	Shale and Sandstone	500–650	Dark shale with sandstone and shale interbedded.
	Sunbury			Black argillaceous bituminous shale.
	Berea s. s.	Berea Grit	30–60	Medium grained gray to buff sandstone.
Devonian or Carboniferous	Bedford sh.	Shale	20–50	Black and brown shale.
Devonian	Ohio Shale: Cleveland shale	Ohio shale	1,300–1,370	Thickens to the East. Black and brown carbonaceous shale, with numerous "iron stone" concretions. Some oil and gas.
	Ohio Shale: Chagrin form			
	Ohio Shale: Huron shale			
	Olentangy shale			
Unconformity	Delaware Limestone	Big Lime	1,030–1,080	Brown, gray, and blue limestones with few thin sandstone and shale beds in the lower half of the formation. A 40 foot salt bed lies 600 feet below top of Delaware limestone. Thickening takes place toward the East.
	Columbus Limestone			
	Monroe			
	Salina form			
	Niagara form			
Silurian	Clinton	Little Lime	150–170	Grey and red sandstone, dark shale with interbedded layers.
		Clinton Sand	5–45	Important oil and gas. Grey or red sandstone.
	Medina shales	Medina Red Rock	?	Red clay and shale. Little known as the drilling stops here.

FIVE MUCROTRICHAPHIS APHIDS[1]

GEORGE F. KNOWLTON AND MERLIN W. ALLEN[2]

This report deals with several species of aphids which are not typical *Macrosiphum*, yet are closely related to that genus. A new genus, *Mucrotrichaphis*, is erected and four of the five species considered are here described as new.

Mucrotrichaphis n. gen.

Mucrotrichaphis may be characterized as having: Weakly developed antennal tubercles which (most typically) scarcely exceed the vertex; slender, pointed hairs on vertex, antennae, body, and hind tibiae; cornicles well developed, cylindrical, imbricated and possessing reticulations; cauda elongate with several pairs of lateral hairs; general body shape as in *Macrosiphum;* antennae equal to or longer than the body; hind tibiae shorter than usual for typical *Macrosiphum;* ocular tubercles present.

Genotype—Mucrotrichaphis toti K.-A.

Taxonomy—Mucrotrichaphis species differ from typical *Macrosiphum* in having pointed rather than knobbed, flattened or blunt hairs on the vertex and antennae, possessing weakly developed antennal tubercles, and in being smaller than the average for *Macrosiphum* species. It differs from typical *Aphis* in having cornicles distinctly reticulated, cauda and antennae more elongate, with more typical *Macrosiphum* body shape. This genus would be more closely related to the Aphina than most genera in the Macrosiphina subtribe.

KEY TO APTERA

A. Unguis exceeding 4 times base of antennal IV.....**toti** n. sp.
AA. Unguis not exceeding 4 times base antennal IV.

B. Cornicles with 2 or 3 rows of reticulations; hairs on dorsum of abdomen not noticeably abundant.....**zerohypsi** n. sp.
BB. Cornicles with 4 to 5 rows of reticulations, hairs on dorsum of abdomen very numerous.....**anomellus** (K.-A.)

KEY TO ALATES

A. Unguis usually 1.75 times cornicles.
B. Sensoria on antennal III exceeding 18 in number.....**flavila** n. sp.
BB. Sensoria on antennal III not exceeding 18 in number.....**toti** n. sp.
AA. Unguis seldom exceeding 1.5 times cornicles.....**albicornus** n. sp.

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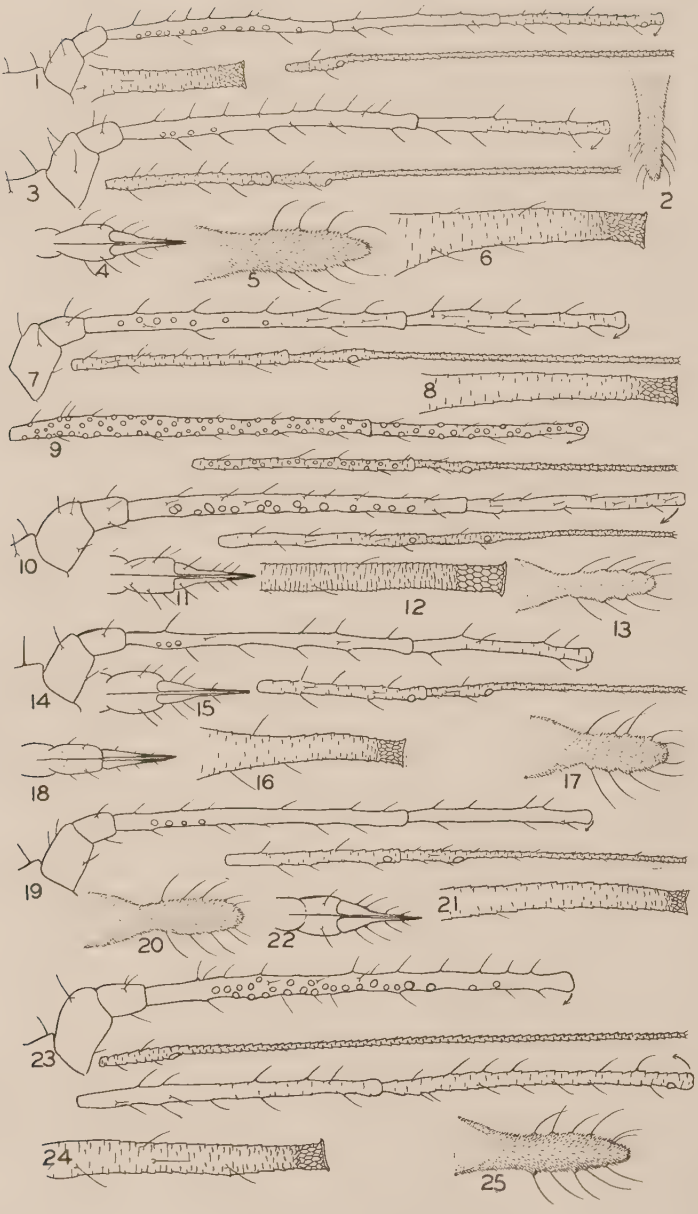
[1]Contribution from the Department of Entomology, Utah Agricultural Experiment station.

[2]Research associate professor of entomology and research assistant, respectively.



LEGEND FOR FIGURE

Mucrotrichaphis toti n. sp., alate 1–2, aptera 3–6, ovipara 7–8, alate male 9. *M. albicornus* n. sp., alate 10–13. *M. anomellus* (K.-A.), aptera 14–17. *M. zerohypsi* n. sp., aptera 18–21. *M. flavila* n. sp., alate 22–25.

Mucrotrichaphis toti n. sp.

Apterous vivipara—Body 1.43 to 1.59 mm. long; antennae 2.1 to 2.15, dark beyond basal one-half of III; antennal III, 0.51 to 0.59 with 2 to 4 sensoria on basal one-half; IV, 0.3 to 0.37; V, 0.3 to 0.34; VI, 0.11 to 0.12+0.51 to 0.62; rostral IV+V, 0.12 to 0.14 mm., reaching 3rd coxae; hind tibiae 0.96 to 1.08; hind tarsi 0.12 to 0.14; cornicles, 0.47 to 0.52, reticulation 0.08, 6 to 8 rows; cauda 0.24 to 0.34 mm. long.

Alate vivipara—Legs, cornicles, cauda and antennae dusky; body, 1.57 mm. long; antennae, 2.05, dark entire length; antennal III, 0.47 mm. with 11 to 12 sensoria in single row; IV, 0.32; V, 0.32; VI, 0.11+0.6; rostral IV+V, 0.12, reaching 3rd coxae; hind tibiae 0.92; hind tarsi 0.12; cornicles 0.3; cauda 0.2 mm. long.

Apterous ovipara—Body 1.33 to 1.54 mm. long; antennae, 2.34 mm., dusky beyond base of III; antennal III, 0.59 to 0.67 with 7 to 8 sensoria in a single row; IV, 0.4 to 0.44; V, 0.4 to 0.44; VI, 0.14+0.59; rostral IV+V, 0.14; hind tibiae 1.29 to 1.45; tibiae swollen and bearing sensoria on basal one-third; hind tarsi 0.13 to 0.14; cornicles 0.4 to 0.53, reticulated; cauda 0.24 to 0.3 mm. long.

Alate male—Body 1.64 mm. long; antennae 2.3; antennal III, 0.71 with approximately 60 sensoria; IV, 0.45 to 0.47 with 30 sensoria; V, 0.4 to 0.47 with 16 sensoria; VI, 0.13+0.5; hind tibiae, 1.25; hind tarsi, 0.14; cornicles 0.14 mm. long.

Collections—Type, 6 miles South of Woodruff, Utah, August 25, 1938 (G. F. Knowlton-D. E. Hardy); on *Artemisia tridentata;* paratypes, Monte Cristo, August 25, 1938 (Knowlton-Hardy); Logan Canyon (Cowley Canyon), August 12, 1934 (T. O. Thatcher) on *A. tridentata;* Logan Canyon (Wood Camp), September 2, 1934 (T. O. T.) on *A. tridentata;* Logan Canyon (Natural bridge trail), October 14, 1934 (T. O. T.) on *A. tridentata;* during 1939 collected in Utah at Allen's Canyon, several places in Logan Canyon, Huntsville, between Woodruff and Monte Cristo (Knowlton); on short sage at Cedar Breaks, Utah, August 9–10, 1939 (H. F. Thornley); and at Elko, Nevada, July 1, 1939 (Knowlton).

Taxonomy—This species differs from *zerohypsi* and *anomellus* in having longer unguis and more reticulation on cornicles.

Mucrotrichaphis albicornus n. sp.

Alate vivipara—Body 1.94 to 2.07 mm. long, color black; antennae 2.31 mm., dusky beyond basal one-half of III; antennal III, 0.61 to 0.67 with 12 to 16 sensoria; IV, 0.38 to 0.44; V, 0.36 to 0.42; VI, 0.12+0.65; rostral IV+V, 0.13 to 0.14, rostrum reaching 2nd coxae; hind tibiae 1.14 to 1.33; hind tarsi, 0.13 to 0.14; cornicles 0.45 to 0.51 with reticulated portions of lighter color than the remainder of cornicles; cauda 0.24 to 0.3 with 4 lateral hairs.

Collections—Type collected on *Artemisia*, Logan Canyon, August 23, 1936 (C. F. Smith); the paratype slide, Cedar Valley, May 10, 1936 (Knowlton-Smith). (This slide also contains an apterous *Prociphilus* sp.) Collected in Cache National Forest, Dry Bread Pond, July 8, 1939, on *Artemisia tridentata* (Knowlton), Smithfield, June 5, 1939 (R. L. Janes).

Taxonomy—This species differs from *M. flavila* and *M. toti* in having a shorter unguis.

Mucrotrichaphis anomellus (K.-A.)[3] n. comb.

Knowlton and Allen, Canad. Ent. 70: 75, 1938 (*Macrosiphum*).

Apterous vivipara—Body 1.43 to 1.96 mm. long; vertex aphis-like, with pointed hairs; antennae 1.96 to 2.15 mm. long, dusky to dark beyond basal half of III; antennal III, 0.51 to 0.67 mm. long, with 2 to 5 sensoria; IV, 0.3 to 0.36; V, 0.26 to 0.34; VI, 0.12 to 0.13+0.37 to 0.45; rostrum attaining 3 coxae; rostral IV+V, 0.14 to 0.16 mm. long; hind tibiae 1.02 to 1.14; hind tarsi 0.12 to 0.14; cornicles 0.43 to 0.49, dusky, with 3 to 5 hairs; cauda dusky, 0.3 to 0.34 mm. long.

Collections—Taken upon *Artemisia tridentata* at Little Cottonwood Canyon, Utah, April 24, 1937 (Knowlton); and Big Cottonwood Canyon, Utah, July 10, 1936 (Knowlton and C. F. Smith).

Taxonomy—This species differs from other species in the presence of numerous pointed hairs on the abdomen, in having fewer reticulations on cornicles than *M. toti* and more than *M. zerohypsi*.

Mucrotrichaphis zerohypsi n. sp.

Apterous vivipara—Body 1.64 to 1.76 mm. long; antennae 2.11 to 2.15 mm., black beyond base of antennal III; antennal III, 0.53 to 0.63 with 4 or 5 sensoria on basal one-half; IV, 0.36 to 0.41; V, 0.36 to 0.4; VI, 0.14+0.43 to 0.47; rostral IV+V, 0.14 to 0.15, reaching 3rd coxae; hind tibiae 1.12 to 1.23, distal one-half black; hind tarsi 0.12 to 0.14; cornicles 0.47 to 0.53, dark; cauda 0.32 to 0.33, dusky.

Collections—On *Artemisia*, one mile south of Dry Canyon (Cache County), Utah, April 8, 1934 (T. O. Thatcher).

Taxonomy—*Mucrotrichaphis zerohypsi* differs from *M. anomellus* in having less reticulation on cornicles and fewer hairs on the abdomen.

[3]In the opinion of the writers and of several taxonomists of whom they inquired, *Macrosiphum anomellus* K.-A., 1938, is not preoccupied by *Macrosiphum anomalae* H.-F., 1931. Proposing a new name for this species would only inject another name into the literature which would need to be surpressed as a synonym.

Mucrotrichaphis flavila n. sp.

Alate vivipara—Body 2.11 to 2.34 mm. long, color dark; antennae, 3.07 mm. long, dusky beyond base of antennal III; antennal III, 0.77 to 0.82 with 20 to 26 sensoria scattered over entire length; IV, 0.54 to 0.57; V, 0.49 to 0.57; VI, 0.13 to 0.16+0.91 to 1.01; rostral, IV+V, 0.15 mm., reaching 2nd coxae; hind tibiae 1.51; hind tarsi 0.16; cornicles, 0.51, dark entire length; cauda 0.34 to 0.35, dark.

Collections—On *Artemisia*, Fishing Bridge, Yellowstone National Park, Wyoming, July 18, 1936 (G. F. Knowlton); Montpelier, Idaho, July 19, 1936 (Knowlton).

Taxonomy—*Mucrotrichapis flavila* differs from *M. albicornus* and *M. toti* in having longer antennae, more sensoria on antennal III and antennal tubercles more prominently developed.

A Thumb-nail Sketch of Animal Biology

A new textbook of animal biology which is in keeping with the present trend toward a panoramic view as an introduction to a field of study. Designed for a one-semester course accompanied by a laboratory, the authors urge the student in the words of Agassiz to "Study nature, not books." An introduction gives a panoramic view of the cell, cell-division, metabolism, nutrition, foods, digestion, respiration, excretion, reproduction and classification respectively in 23 pages. The major Phyla then are treated in the usual order with the discussion of the life processes in a selected "type-form." The vertebrate forms used are the perch and the frog. A discussion of Hormones and Vitamines; Mitosis, Spermatogenesis and Oogenesis; Heredity, Genetics and Evolution complete the textual part of the book, a total of 449 pages. An appendix includes a table of animal classifications which are annotated, and a glossary.

The book is well written in language which the beginner should be able to understand. The authors and publishers are to be complimented upon the format and illustrations; mechanically it is an admirable job.

If this text be used in the manner suggested by the author's preface it will doubtless be a contribution rather than an addition to the long list of available zoology textbooks.—*P. E. Sheaffer.*

An Introduction to Biology, by John B. Parker and John J. Clarke. 503 pp. St. Louis, The C. V. Mosby Company. 1939. $3.75.

The Elements: Stories of Their Discovery

"The material blessings that man enjoys today have resulted largely from his ever-increasing knowledge of about ninety simple substances, the chemical elements, most of which were entirely unknown to ancient civilizations . . . . it is hoped that these chapters may not only render tribute to the honored men and women who helped to reveal the hidden chemical elements, but that they may also serve to acquiant chemists and others with these great achievements . . . . an attempt has been made to relate all important steps in the discovery (of the elements) as fairly and completely as possible . . . . ." These exerpts from the Foreword describe the book. This fourth edition is enlarged and revised. The material is interestingly written, well documented and pleasingly enriched with a wealth of pictorial material. The simple, novel style of presentation makes the book interesting to a teacher as well as a student. The treatment of each topic seems to be complete without quibbling; this serves to contribute to the authenticity of the subject material and to increase one's confidence in the validity of the conclusions of the author. This book well deserves a foremost place in historical chemical literature.—*A. B. Garrett.*

Discovery of the Elements (Fourth Edition) by Mary Elvira Weeks. v+470 pp. Easton, Pa., Mack Printing Company, for the Journal of Chemical Education. 1939. $3.50.

A NEW ACMAEODERA FROM THE SOUTHWEST (COLEOPTERA: BUPRESTIDAE)

JOSEF N. KNULL
The Ohio State University, Columbus, Ohio

Acmaeodera paradisjuncta n. sp.

Male—Resembling *A. disjuncta* Fall in form and markings. Elytra black with irregular yellow and red markings. Head, pronotum and ventral surface black with cupreous reflection. A yellow lateral stripe on each side of pronotum not extending to the borders.

Head concave, densely coarsely punctured, pubescence moderately long; eyes large, finely granulate; antennae not reaching to middle of pronotum, serrate from the fifth joint.

Pronotum much wider than long, widest near base; side margins visible throughout from above, broadly rounded from near base toward anterior end, acutely rounded at base; disk convex, a slight median depression, another deep depression on each side at base; surface coarsely punctured, punctures separated by more than their own diameters in middle, more numerous in front, at base and along sides, pubescence moderate.

Elytra slightly wider than widest part of pronotum, widest near base; sides constricted at base and middle, flared nearly horizontally back of middle; margins serrate from middle to apices; disk convex, umbone prominent, eighth interspace prominently raised back of middle, ninth flattened; surface with punctures of striae moderate in size, separated by about their own diameters, much larger along sides, punctures of interspaces small, pubescence moderate.

Front margin of prosternum retracted, sides not reaching the front angles, prosternum trisinuate in front. Abdomen coarsely punctured; last ventral with a thick subapical plate. Pubescence of ventral surface moderately long.

Length, 10.8 mm.; width, 4.2 mm.

Female—Slightly more robust than the male.

Holotype male labeled Davis Mts., Texas, June 8; allotype from Reeves County, Texas, June 12 (D. J. & J. N. Knull, Collectors). Other records include: Texas—Chisos Mts., June 9, Davis Mts., Sept. 8, Terrell County, June 6 (D. J. & J. N. Knull); Chisos Mts., July 19 (H. A. Wenzel). Mexico—Three specimens without definite localities.

Type, allotype and paratypes in writer's collection; paratypes in collection of The Ohio State University and of C. A. Frost, who kindly compared material with the LeConte types.

This species closely resembles *Acmaeodera disjuncta* Fall and undoubtedly is confused with it in collections. It can be separated by its less robust structure and by the flare of the sides of the elytra. The male genitalia of the two species are also distinct. It falls in the Sinuata Group according to Fall[1] and should come next to *disjuncta* Fall.

[1]H. C. Fall. Jour. N. Y. Ent. Soc., Vol. 7, p. 5, 1899.

FACTORS WHICH AFFECT THE GROWTH OF A COLORLESS FLAGELLATE, ASTASIA KLEBSII, IN PURE CULTURES*

HERMAN VON DACH
Mary S. Muellhaupt Scholar in Zoology,
The Ohio State University

INTRODUCTION

This paper is the first of a series of studies on various factors affecting the growth and decline of populations of a protozoan, *Astasia klebsii*, in pure clone culture. In the past, a number of similar investigations have been made on pure cultures of bacteria and yeasts, but very few on the protozoa. The great importance of working with *pure* (i. e., bacteria-free) cultures under controlled conditions is now generally recognized (see Phelps, 1935), and need not be elaborated upon here. In the present paper growth is considered in relation to hydrogen ion concentration, type and concentration of food material, and oxygen tension.

This work has been done under the supervision of Professor W. J. Kostir, of The Ohio State University, who suggested the general problem and supplied the clone culture of *Astasia klebsii*. I am grateful to him for suggestions and criticisms.

THE ORGANISM

The species used in these experiments was *Astasia klebsii*, first described by Lemmermann in 1910, and further studied and described by Pringsheim (1936). The shape of this colorless flagellate is at times altered by protoplasmic contractions, known as euglenoid movements or metaboly. Nutrition is saprozoic. Food reserves of paramylum, a starch-like polysaccharide which does not respond to the usual iodine test for starch, are stored as small granules in the cell. No thick-walled resting stage is known. The cells of the strain used in this investigation measure 40 to 50 microns in length by 10 to 15 microns in width; these dimensions conform more closely to Pringsheim's description than to Lemmermann's.

*Contributions from the Department of Zoology and Entomology, Number 114.
Most of the material included in this paper forms part of a dissertation submitted to the graduate school of The Ohio State University in partial fulfillment of the requirements for the degree of doctor of philosophy, June, 1939.

The delicate striation of the pellicle, mentioned both by Lemmermann and by Pringsheim, is not easily seen, but is definitely demonstrable with the best optical equipment.

This species has not previously been studied in bacteria-free culture.

MATERIALS AND METHODS

Cells from a stock clone culture of *Astasia klebsii* were washed bacteria-free, employing the "migration-pipette" method of Glaser and Coria (1930), and pure cultures were established.

The following inorganic solution was used as the basis of all culture media:

KNO_3	0.5 g.
KH_2PO_4	1.5 g.
$MgSO_4.7H_2O$	0.1 g.
NaCl	0.1 g.
$CaCl_2$	0.01 g.
$FeCl_3$	trace
Triple-distilled water (Distilled in Pyrex still)	1 liter

The following culture media were used:

Medium B-1: 1.0 g. Bacto-Tryptone per liter of inorganic solution.

Medium B-5: 5.0 g. Bacto-Tryptone per liter of inorganic solution.

Medium B-25: 25.0 g. Bacto-Tryptone per liter of inorganic solution.

Medium C: 2.0 g. anhydrous sodium acetate per liter of Medium B-5.

The pH of each medium was adjusted to the desired level by addition of N/1 HCl or N/1 NaOH, colorimetric determinations being made with a Hellige comparator. 9.3 cc. portions of medium were measured into 20 x 150 mm. Pyrex culture tubes which were then plugged with cotton and autoclaved.

A single flask culture was used as the source of the inoculum in an experiment. Equal volumes of inoculum were transferred to dilution flasks of the various types of media employed; from each dilution flask in turn 1.0 cc. portions were transferred to the culture tubes of the corresponding series. In this way the original inoculum was greatly diluted (from 50 to 1000 volumes in different experiments).

The initial number of cells per cc. was determined. After varying periods of incubation (at 25° C. ± 1° unless otherwise noted) the final number of cells per cc. was determined. Cell counts were made by the Sedgwick-Rafter counting method as described by Hall, Johnson, and Loefer (1935). In each instance the mean count of several samples from three cultures was computed. Increase in number of cells was the only criterion of growth studied.

The customary bacteriological techniques and tests for purity of the cultures were employed. Contaminated cultures were discarded.

TABLE I

Effect of pH on Growth in 0.5% Tryptone
Medium B-5 used in all series.
Inoculations from a Medium B-5 culture at pH 5.8.
Initial cell concentration = 420 cells per cc.

Culture Series	No. Cells per cc. at 4 Days	No. Cells per cc. at 8 Days	Final pH
Series A—Initial pH 3.2	1,400	10,360	3.2
Series B—Initial pH 4.2	4,220	29,330	4.2
Series C—Initial pH 5.1	12,110	29,980	5.2
Series D—Initial pH 6.0	13,940	31,830	6.0
Series E—Initial pH 7.0	3,830	13,310	7.0
Series F—Initial pH 7.9	1,890	3,770	7.8
Series G—Initial pH 8.4	1,720	2,540	8.2

EFFECT OF HYDROGEN ION CONCENTRATION

Hydrogen ion concentration has long been recognized as an important ecological factor affecting the growth of protozoa. Various workers have determined the pH relationships of a number of protozoa in pure culture, including several species of *Euglena;* these results were summarized by Loefer (1935). The first two experiments of the present study dealt with the effects of this factor in two different types of medium: 0.5% tryptone (Medium B-5), and acetate-tryptone (Medium C).

In 0.5% tryptone at eight days there was optimum growth at pH 6.0, a range of nearly equal growth between pH 4.2 and 6.0, less growth at pH 3.2 and 7.0, and very little growth at

pH 7.9 and 8.4. (See Table I.) The limits of the pH range of growth were not revealed by this experiment. Comparison of these results with those given for other euglenoids in Loefer's (1935) table of pH relationships shows that *Astasia klebsii* has a wider pH range of growth and a lower optimum pH than most previously-studied members of the group.

In acetate-tryptone, maximum growth was at pH 5.1 and 5.9, with good growth occurring over the range pH 4.4 to 6.7, much less growth at pH 7.4 and 8.2, and no growth at all at pH 3.8. (See Table II.)

TABLE II

EFFECT OF pH ON GROWTH IN ACETATE-TRYPTONE
Medium C used in all series.
Inoculations from a Medium C culture at pH 5.9.
Initial cell concentration = 100 cells per cc.
Incubation at 26.5° C. (±0.5°).

CULTURE SERIES	AT 4 DAYS		AT 8 DAYS	
	No. Cells per cc.	pH	No. Cells per cc.	pH
Series A—Initial pH 3.8	60	3.8	50	3.8
Series B—Initial pH 4.4	1,460	4.4	310,600	4.7
Series C—Initial pH 5.1	6,600	5.1	764,000	7.6
Series D—Initial pH 5.9	6,920	5.9	748,000	8.2
Series E—Initial pH 6.7	4,320	6.7	228,200	7.5
Series F—Initial pH 7.4	1,580	7.4	11,600	7.4
Series G—Initial pH 8.2	550	8.2	960	8.1

Comparison of Table I and Table II shows that addition of acetate to 0.5% tryptone medium greatly increases growth over the range pH 4.4 to 6.7, has little effect above pH 7.0, and completely inhibits growth at pH 3.8.

In the foregoing experiments, the tryptone cultures and the acetate-tryptone cultures had been inoculated from different source cultures and had been run at slightly different temperatures. As a further check on these general results, another experiment was performed to compare growth at pH 5.9 in 0.5% tryptone and in acetate-tryptone, making inoculations

from a single source culture. The results, presented in Table III, clearly show the great increase in growth produced at this pH by addition of acetate to the tryptone medium.

In Table III the marked increase in pH in the acetate-tryptone cultures is in contrast to the constancy of pH observed in the tryptone cultures. The same phenomenon was observed in the other experiments included in this paper. In general, the pH of tryptone cultures remained practically constant; on the other hand, in vigorously-growing cultures in acetate-tryptone medium there was a marked increase in pH. The following tentative explanation is suggested: Probably the sodium

TABLE III

GROWTH IN TRYPTONE AND IN ACETATE-TRYPTONE AT PH 5.9
Inoculations from a Medium C culture of pH 5.9.
Initial cell concentration of cultures = 1700 cells per cc.

Culture Series	At 3 Days		At 8 Days	
	No. Cells per cc.	pH	No. Cells per cc.	pH
Series A Medium C Initial pH 5.9	141,990	6.7	702,520	8.3
Series B Medium B-5 Initial pH 5.9	53,390	5.9	57,840	5.9

acetate partly hydrolyzes to form sodium hydroxide and acetic acid, the acetic acid being oxidized by the cells to CO_2 and water; the accumulation of sodium bicarbonate and sodium hydroxide results in a gradual alkalinization.

According to the review by Hall (1939), it has been shown that acetate increases growth in a number of saprozoic flagellates, including three other species of *Astasia*. The toxic effect of acetate on protozoan cultures at low pH was discussed by Jahn (1934). He suggested that at low pH much of the acetate would be in the form of undissociated acetic acid, and that only the undissociated acetic acid molecule was toxic.

EFFECT OF OXYGEN TENSION

It has been shown that cultures in acetate-tryptone at pH 5 or 6 develop dense concentrations of cells (700,000 cells per

cc.); this suggested that this species may be anaerobic or nearly so. As Rahn (1932, p. 80), speaking of bacteria cultures, says: "There can be no doubt that in a test-tube culture or flask culture of aerobes, all cells will exist under practically anaerobic conditions except those in the very top surface layer." Likewise, Pringsheim (1936) had grown bacteria-containing cultures of *Astasia klebsii* under films of paraffin oil, which points to the same possibility. To test this point, the experiment summarized in Table IV was performed, employing acetate-tryptone of initial pH 5.9 as the culture medium.

TABLE IV

Effects of Oxygen Tension on Growth in Acetate-Tryptone
Medium C (initial pH 5.9) used in all series.
Inoculations from a Medium C culture of pH 5.9.
Initial cell concentration of cultures = 1700 cells per cc.

Culture Series	At 3 Days		At 8 Days	
	No. Cells per cc.	pH	No. Cells per cc.	pH
Series A—Control	141,990	6.7	702,520	8.3
Series B—Nearly Anaerobic	41,040	6.2	549,400	7.6
Series C—Constant Aeration	41,140	6.2	638,960	8.4

In this experiment the cultures of one series (B) were treated as follows: Each newly-inoculated culture tube was fitted with a rubber stopper equipped with a glass inlet tube extending almost to the bottom of the culture tube and an outlet tube which came only to the bottom of the rubber stopper. Tank nitrogen was shaken in a pressure bottle containing strong pyrogallate solution to absorb almost all the oxygen present. The treated gas was sterilized by passing through cotton, saturated with water vapor and then bubbled vigorously through the cultures for 12 minutes, after which the gum rubber connections on inlet and outlet tubes were clamped off. Culture tubes so treated presumably contained only minute amounts of oxygen; but they could not be regarded as completely oxygen-free, for pyrogallate solution does not absorb every trace of oxygen, and also oxygen can diffuse through rubber tubing.

In another series (C) the culture tubes were fitted with rubber stoppers and glass tubing as in Series B, and a constant stream of sterilized water-saturated air was bubbled through the cultures during the entire period of incubation.

The oxygen tension in the cotton-plugged controls (Series A) was presumed to be more or less intermediate between that in Series B and that in Series C.

It will be seen from Table IV that both the constantly-aerated cultures (Series C) and the nearly anaerobic cultures (Series B) showed lower growth rates, but also showed longer periods of comparatively vigorous growth, than the controls of Series A. As a result, at eight days the population levels in the former two series were not greatly less than that of the controls. Jahn (1936), working with the ciliate *Glaucoma pyriformis* and the flagellate *Chilomonas paramecium*, studied growth in aerated cultures and in non-aerated cultures; his results agree on the whole with those of the corresponding part of the present experiment.

EFFECT OF DIFFERENT CONCENTRATIONS OF TRYPTONE UPON THE GROWTH CURVE

Among the bacteria and yeasts considerable work has been done on the determination of the various phases of the growth curves, and on the factors affecting these phases. In much pure-culture work on the protozoa, however, the general practice has been to determine relative amounts of growth after only one or two arbitrarily-chosen periods of incubation. Sometimes it is assumed that logarithmic growth-rates are being determined, but usually no attempt is made to differentiate between the various phases of the growth curve. As a result, such work on the protozoa has lacked completeness and precision. The results summarized in Tables I and II of the present paper illustrate the shortcomings of this procedure. A fuller and more satisfactory picture of the growth of a culture is afforded by growth curves—especially logarithmic curves, in which the various phases of growth can readily be seen at a glance.

The only published detailed study of the growth curve of a protozoan in pure culture is that on the ciliate *Glaucoma pyriformis* by Phelps (1935, 1936). He compared his findings on this form with the data on the growth curves of yeasts and bacteria as summarized by Buchanan and Fulmer (1928) and by Rahn (1932).

The obvious desirability of ascertaining the rate of growth at various stages in the development of astasia cultures, and thus constructing true growth curves, led to the following procedure. An experiment was undertaken to determine the course of growth in tryptone media of 0.1%, 0.5%, and 2.5% concentrations. Inoculations were made from a 7-day-old culture in 0.5% tryptone which was probably in the logarithmic growth phase. Initial cell concentrations of the cultures were 400 cells per cc. The hydrogen ion concentration of all cultures remained constant at pH 5.8. The results of this experiment are presented in Figure 1.

Buchanan and Fulmer (1928) divide the growth curve of bacteria into the following phases: (1) the initial stationary phase, during which no cell division occurs; (2) the lag phase, during which the division rate increases with time; (3) the logarithmic growth phase, during which the rate of cell division is constant and at a maximum; (4) the phase of negative growth acceleration, during which the division rate decreases with time; (5) the maximum stationary phase, during which the population is constant and at a maximal level; (6) phase of accelerated death, during which the rate of decrease in the number of living cells increases with time; (7) so-called logarithmic death phase, during which the rate of decrease of living cells is constant. In this paper only the first five phases of growth will be discussed.

In the present experiment, though counts were made at rather wide intervals, the general trends of the growth curves are fairly clear. (See Fig. 1.)

No initial stationary phase is evident from the data at hand.

The growth curve of the 0.5% tryptone cultures showed a very brief and ill-defined lag phase which went quickly into the logarithmic growth phase. The 0.1% tryptone cultures showed a longer and more well-defined lag phase, which was still more pronounced in the 2.5% tryptone cultures.

Concerning a similar situation, Phelps (1936) states: "Animals [*Glaucoma*] taken from the stock cultures containing 0.1% yeast extract, upon being placed in much higher concentrations suffered a shock, and failed to divide for sometimes as much as 30 hours." In the present experiment it may be postulated that astasias from the 0.5% tryptone inoculum suffered some shock on transfer to medium of a different tryp-

tone concentration, whether higher or lower, and this shock resulted in a well-defined lag phase of growth.

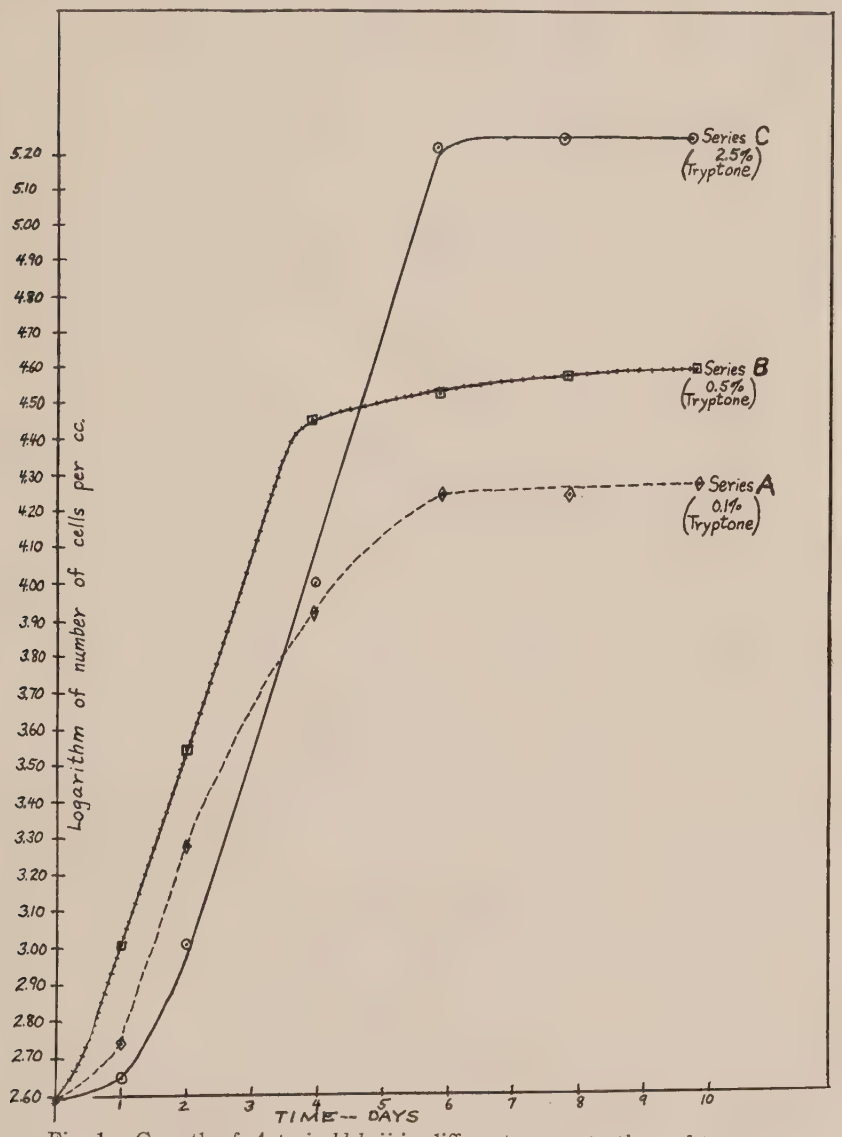


Fig. 1. Growth of *Astasia klebsii* in different concentrations of tryptone.

Logarithmic growth phase. When the logarithm of the number of cells per cc. is plotted against time, this part of the growth curve will be an ascending straight line. (See Fig. 1.)

The time required for the number of cells in a culture to double (presumably by each cell dividing into two cells) is called generation time (g). During the logarithmic growth phase g is a constant. According to Rahn (1932) the standard formula for generation time is

$$g = \frac{t \log 2}{\log b - \log a}$$

where a = initial number of cells, and b = number of cells after time t. Applying this formula to the logarithmic growth periods of the cultures in this experiment, the values given in Table V were obtained.

TABLE V

GROWTH RATES IN LOGARITHMIC PHASE IN DIFFERENT CONCENTRATIONS OF TRYPTONE

Culture Series	Portion of Logarithmic Growth Period Taken in Calculation of g	g Generation Time of Logarithmic Phase
Series A—0.1% tryptone	1 day to 2 days	13.6 hours
Series B—0.5% tryptone	1 day to 2 days	13.4 hours
Series C—2.5% tryptone	2 days to 6 days	13.1 hours

Table V shows that in the logarithmic growth phase the generation time is practically constant in tryptone concentrations between 0.1% and 2.5%. However, the duration of the logarithmic growth phase increased with increasing food concentration, as Figure 1 shows.

At the end of the logarithmic growth phase, the growth curves of Series B and C showed abrupt decline in division rate as the phase of negative growth acceleration began; while the curve of Series A showed a prolonged gradual decline in growth rate.

Maximum stationary phase. In each series of cultures, the cell concentration at 20 days and at 22 days was very slightly less than that at 10 days. Consequently the cell concentration at 10 days may be regarded as the maximum yield in each case.

According to Rahn, when the maximum populations are proportional to the concentrations of food in the medium, then food is the sole limiting factor of the growth of the populations,

and accumulation of metabolic wastes plays no part in such limitation.

In Table VI, Series B and C show such a proportionality between yields of cells and concentrations of medium, indicating that possibly food supply is here the limiting factor. Yet this relationship between food and cell yields breaks down when the weaker concentrations of food are compared (Series A and Series B).

No explanation is available for this discrepancy. Phelps (1936) found the same general sort of situation in *Glaucoma:* namely, that there was a proportionality between yields of animals and concentrations of medium, which however did not hold true for very weak food concentrations.

TABLE VI

Food Concentrations and Maximum Populations

Culture Series	Food Concentration Ratio (tryptone)	Maximum Populations (No. Cells per cc.)	Ratio of Maximum Populations
Series A	0.1%	18,330	0.48
Series B	0.5%	38,100	1.0
Series C	2.5%	173,100	4.54

Besides the points already mentioned, the following conclusions from the present experiment are in substantial agreement with Phelps' results on *Glaucoma:* (1) The generation time during the logarithmic growth phase is approximately the same at several concentrations of food; (2) there is an increase in duration of the logarithmic growth phase with increasing food concentration.

SUMMARY

Bacteria-free clone cultures of *Astasia klebsii* in 0.5% tryptone medium after 8 days at 25° C. showed optimum growth at pH 6.0, a range of nearly equal growth between pH 4.2 and pH 6.0, less growth at pH 3.2 and pH 7.0, and very little growth above pH 7.0.

Addition of acetate to the tryptone medium greatly increased growth over the range pH 4.4 to 6.7, had little effect above pH 7.0, and completely inhibited growth at pH 3.8.

In tryptone cultures pH remained practically constant, while in vigorously-growing acetate-tryptone cultures there was a marked increase in pH.

In acetate-tryptone at initial pH 5.9, both nearly-anaerobic cultures and constantly-aerated cultures showed slower growth than the controls, but the yields of all three series of cultures after eight days were fairly comparable.

Growth curves were determined at 25° C. for three different concentrations of tryptone (0.1%, 0.5%, 2.5%). During the logarithmic growth phase the generation time was slightly greater than 13 hours at all three food concentrations; duration of this phase increased with increasing concentration of tryptone. In the case of the 0.5% and 2.5% tryptone cultures the maximum populations were roughly proportional to food concentration, but this proportionality did not hold for the 0.1% tryptone cultures.

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THREE NEW SPECIES OF PSYLLIDAE WITH NOTES ON OTHERS

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Livia aba n. sp.

Length to tip of forewing 3.2 mm.; forewing 2.2 mm.

Color: Head and thorax brownish red above; venter black. Abdomen brown above with white venter. Forewings yellowish.

Vertex angulate in front as in *coloradensis* Crawford. Eyes rather prominent for the genus. Forewings with membrane rugose but hyaline.

Dorsal valve of female greatly arched in caudal half with extreme apical portion suddenly narrowed to a short blunt apex. Ventral valve narrowly triangular in lateral aspect.

Female holotype from Yellowstone Park, Wyoming, collected by Herbert Osborn, is in his collection at Ohio State University.

Livia vernaliforma n. sp.

Length to tip of forewing 3 mm.; forewing 2.2 mm.

Color: Golden yellow washed with orange. Venter of head and thorax black. Forewings very light yellow.

Vertex short but emarginate in front similar to *vernalis* Fitch. Forewing over twice as long as broad; membrane hyaline, rugose.

Dorsal valve of female similar to *vernalis* except much more sinuate with a much narrower apex; ventral valve not as heavy.

Female holotype, Williston, N. D., collected by Herbert Osborn, is in his collection at Ohio State University.

Trioza sembla n. sp.

Length to tip of forewing 2.7 mm.; forewing 2.2 mm.

Color: Light orange except for black eyes, black antennae beyond second segment, brown tarsi, and yellow margin around vertex.

Head as broad as thorax, both finely pubescent. Genal cones two thirds as long as vertex, acute, slightly divergent. Antennae a little longer than width of head. Forewings little over twice as long as broad; apices subacute.

Proctiger of male with large caudal lobes. Forceps shorter than proctiger. In lateral aspect: Caudal margin practically straight, cephalic margin slightly produced cephalad, apices slightly rounded rather than truncate. In caudal aspect: thick basally, slightly bowed, narrowed evenly to apices.

Male holotype, Painted Desert, Ariz., VI-25, D. J. and J. N. Knull collectors, is in the Ohio State University collection.

Aphalaroida masonici n. n.

This species was described as a species of Euphyllura with some doubt as to placement. Since the frons is visible, although very

indistinct, the species belongs in *Aphalaroida*. The name *acacia* is preoccupied by Crawford's species so the name *masonici* is proposed. (Ann. Ent. Soc. Amer. 31: 442, 1938.)

Psylla tuthilli n. n.

Mr. Tuthill has called the writer's attention to the fact that the name *virida* is preoccupied by *viridis* Hartig. The writer takes pleasure in naming this species after Mr. L. D. Tuthill of Iowa State College. (Can. Ent. 71: 212, 1939.)

Phylloplecta minuta Crawford

Mr. Oman has called attention to the fact that the writer errored in proposing the name *multidubiata* for Mallys' *salicis*. The name should be *minuta* Crawford. It also follows that the variety *P. multidubiata breviradia* should be changed to *P. minuta breviradia*. (Can. Ent. 71: 211, 1939.)

Quantitative Zoology

Until recent years zoology has generally been considered a non-mathematical science. As a consequence, many professional zoologists have had only an elementary training in mathematics, and no training whatsoever in the use of statistics. The development of statistical techniques and their applications to the interpretation to various types of data have become so widespread in the last few years that zoologists can ill afford to be without at least an elementary understanding of statistical principles. While numerous statistics texts have recently appeared, many are of a too technical and advanced nature for the beginner.

The new book "Quantitative Zoology," by Simpson and Roe is designed to meet the needs of the zoologist who has had no training in statistics. The book is primarily a text on methodology in zoology, and includes, in addition to the portions on general statistics, chapters on Types and Properties of Numerical Data, Mensuration, Graphic Methods and Growth. The authors are paleontologists and present their material from the standpoint of the zoologist and paleontologist. Twelve chapters deal with elementary statistics as applied to zoological data, including treatments of correlation, regression and tests of association. They have not followed Fisher in using a double set of symbols and terms, one for the parameters of populations and one for the calculated estimates of these parameters. The text presupposes no knowledge whatever of statistics, and of mathematics no more than elementary algebra. The appendix contains sections on calculations, symbols, formulae and a glossary. Quantitative Zoology appears to be admirably adapted to the zoologist and paleontologist, as a practical guide in the interpretation of many types of data.—*D. C. Rife.*

Quantitative Zoology, by George Gaylord Simpson and Anne Roe. xvi+414 pp. New York, McGraw-Hill Book Company, Inc. 1939. $4.00.

BOOK NOTICES

Principles of Genetics

Rapid advances in our knowledge of chromosomal aberrations, polyploidy, giant chromosomes, sex determination, developmental genetics, the effects of various types of selection, and simple applications of tests for goodness of fit have been made in recent years. In their third edition of "Principles of Genetics," Sinnott and Dunn have included up to date discussions of all the above phases of modern genetics. The material is presented with unusual clarity. The order of topics is much the same as in the earlier editions. Excellent problems are given at the end of each chapter. Illustrations and diagrams are numerous.

We have only two adverse criticisms, both of a minor nature. Too much material is given in some of the chapters for the average beginning student to grasp easily. For example, Chapter V, entitled the Expression and Interaction of Factors, includes not only modifications of two factor crosses, but also multiple alleles, modifying factors, multiple effects of a single factor and lethal factors. In many of the problems assumptions are made which are not justified. For example, blue eyes and left-handedness are assumed to be simple recessives. Numerous instances of clear cut simple factor traits, such as albinism and polydactylism are known, and would seem more appropriate as problem material.

The book is an unusually good text for superior beginning students, especially those intending to major in some phase of biology.—*D. C. Rife.*

Principles of Genetics (3rd edition), by Edmund W. Sinnott and L. C. Dunn. xvi+408 pp. New York, McGraw-Hill Book Co., Inc. 1939.

Adult Intelligence

There has finally been composed a good clinical test of adult intelligence; a test based on the development of psychological functions throughout the span of adult years, rather than on the years during which the growth of intellectual capacities is most marked. The direct outcome of this effort is that we may now determine the relative brightness of adults without having to resort to scores whose relationship with the factor of age is undetermined, and therefore of questionable significance.

"The Measurement of Adult Intelligence" is the published account of the logic and method employed by Dr. David Wechsler in constructing the "Bellevue Intelligence Examination." The examination is arranged as a point scale to be administered individually, and is composed of ten tests; five verbal tests and five tests of performance. Scores may be obtained for the verbal or performance aspects as well as for the full scale—depending on the clinical purpose.

The book is divided into three main parts; the nature and classification of intelligence, the description of the tests and their standardization as a scale, and the directions for administering the tests plus statistical appendices and I. Q. tables. Without detracting one bit from Dr. Wechsler's accomplishment, it should be said that pracically all of the principal concepts employed by him have been described before. His main contribution lies in his combination of these features into a practical and sound measure of adult intelligence.

The chief characteristic of the book, as of the examination it describes, is the application of normal frequency statistics to groups arranged on the basis of age and score. Since the function of the I. Q. is to provide an index of relative brightness, the author devises just such an index by measuring intelligence at each age and obtaining standard scores for each year level. The comparable units resulting from this procedure yields an index which has the same function at any age, and therefore "maintains the same meaning throughout the life of the individual." A

similar application of the Probable Error to the problem of classification yields levels such as "normal," "superior" and "defective" which are of uniform significance for any intelligence test at any age.

One of the most interesting of the theoretical sections of the book deals with the problem of mental deterioration. Employing a "rate of change" concept, Dr. Wechsler lays the foundation for a precise method of measuring psychological effects of deterioration. The essence of the scheme involves measurement of the rate of decline characteristic of various test abilities. Since certain abilities are affected only slightly by age (after 25) while others are markedly affected, the relative difference between the two should be the greater the longer the period of deterioration, or the more severe its effects. The author points out, however, that the problem is not as simple as it may appear on the surface. The complications yet to be eliminated concern determination of the limits of normal deterioration, interpretation of the large variations in the deterioration of different individuals (making application to single cases difficult) and determination of differences in deterioration occasioned by the various neuropathic disorders.

In presenting the results of standardization Dr. Wechsler gives adequate proof that the Bellevue scale is reliable as well as valid, since it correlates highly with itself and with the Stanford-Binet. In this connection one point is of special interest. A bi-serial correlation between Stanford-Binet I. Q.'s and psychiatric recommendations gave a coefficient of $.33 \pm .071$. The same procedure using the Bellevue examination yielded a bi-serial coefficient of $.79 \pm .048$. It is obvious, therefore, that the measure of intelligence given by the Bellevue examination, although having much in common with that given by the Stanford-Binet, has a decided clinical emphasis.

The book is a clear account of that which the author has thought and done, and leaves few questions to be asked.—*Milton M. Parker.*

The Measurement of Adult Intelligence, by David Wechsler. ix+229 pp. Baltimore, the Williams and Wilkins Co. 1939. $3.50.

Laboratory Guide in Entomology

Anyone teaching an introductory course in entomology will want to examine the new laboratory guide prepared by Prof. Robert Matheson for the introductory course in entomology at Cornell University. This guide covers a diversified field of subject matter and presents the same in an excellent manner. Some of the topics covered are external and internal anatomy including types of mouth-parts; characteristic structures of the adults of the most important orders, and keys to families; adaptations among insects; social life; insects as pollinators; relationship to disease of man and animals; the problem of control, etc. At the end of the book there occurs a short chapter on how to collect, prepare, mount, preserve and rear insects and a short glossary of scientific terms. Many excellent drawings are found throughout the guide which students are asked to label.—*A. Peterson.*

A Laboratory Guide in Entomology by Robert Matheson, 135 pp. Ithaca, The Comstock Publishing Co., Inc. 1939. $2.00.